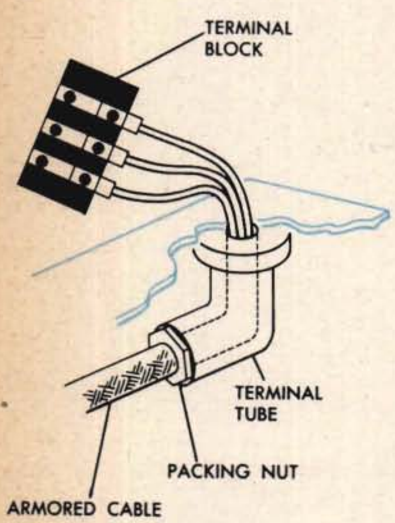
WIRING

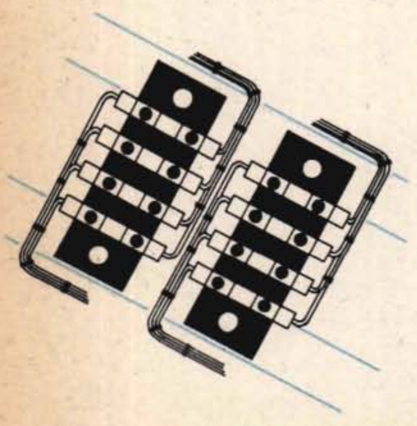


Ship's wiring

The ship's wiring is bound in armored or in rubber-sheathed cables. These cables enter the instrument through terminal tubes equipped with packing nuts and glands to make a water seal. Inside the instrument, the armor or sheathing is cut off flush with the terminal tube and the wires are led to terminal blocks. Each wire terminal is attached to a bus bar according to the designation number stamped on the block. For information on ship's wiring, refer to the ship's wiring diagram.

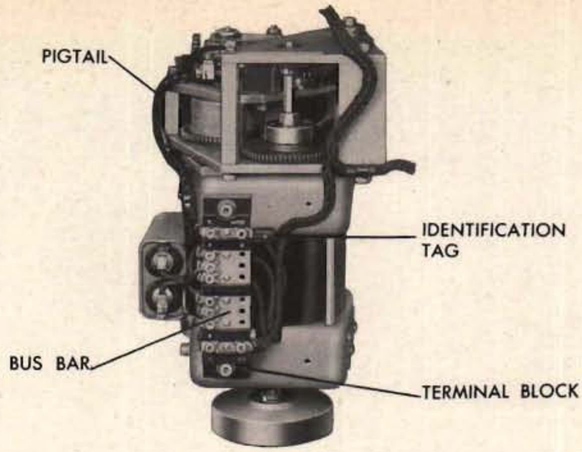
Instrument wiring

The instrument wiring leads from these blocks to individual units in the instrument. Usually, the instrument wiring is bound into cables which are led to intermediate terminal blocks in different sections of the instrument before single wires are led to the terminal blocks on the various electromechanical units.



Identifying wires

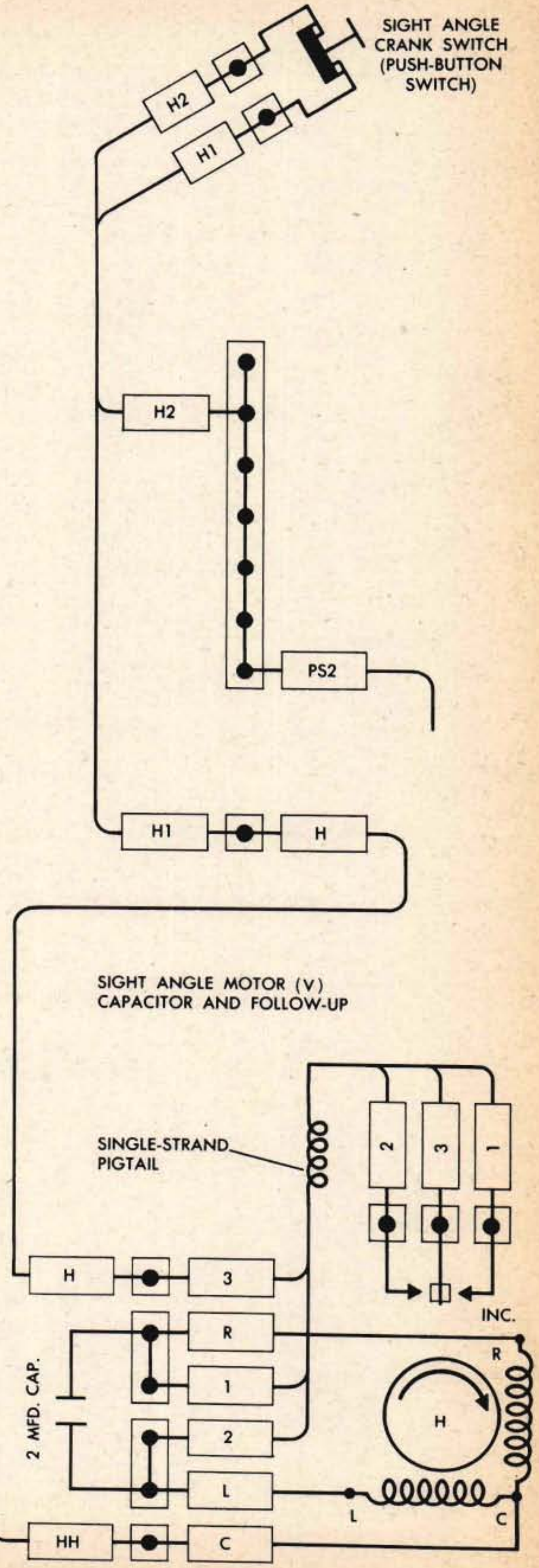
Letters are assigned to distinguish the different circuits. Numbers are added to the letters to distinguish the individual wires in the circuits, each wire having the same designation at both ends. In the instrument, these designations appear wherever a connection is made. They are stamped on the identification tags at the ends of the wires, on the terminal blocks, and on the units. These designations also appear on the instrument wiring diagrams, appropriately connected by lines. In order to facilitate reading, lines which have the same destination are merged to keep the number of lines at a minimum. Where lines cross each other, always go straight across, never turn to the left or to the right. The place where two lines merge or cross *does not* indicate a common connection. A common connection, which usually involves the use of a bus bar or a terminal post, is indicated by ─⊡─ . A soldered connection, usually made inside a unit, is indicated by ─•─ .

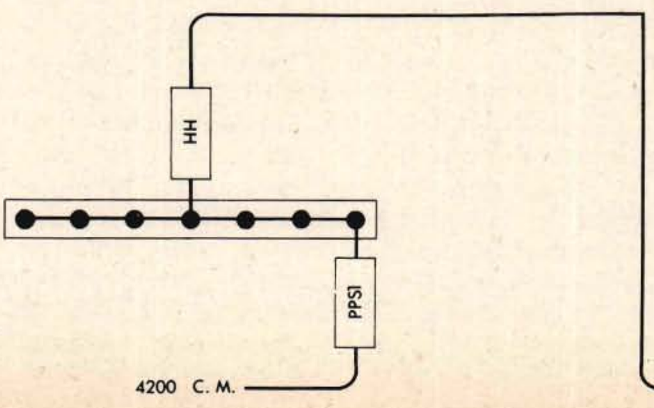


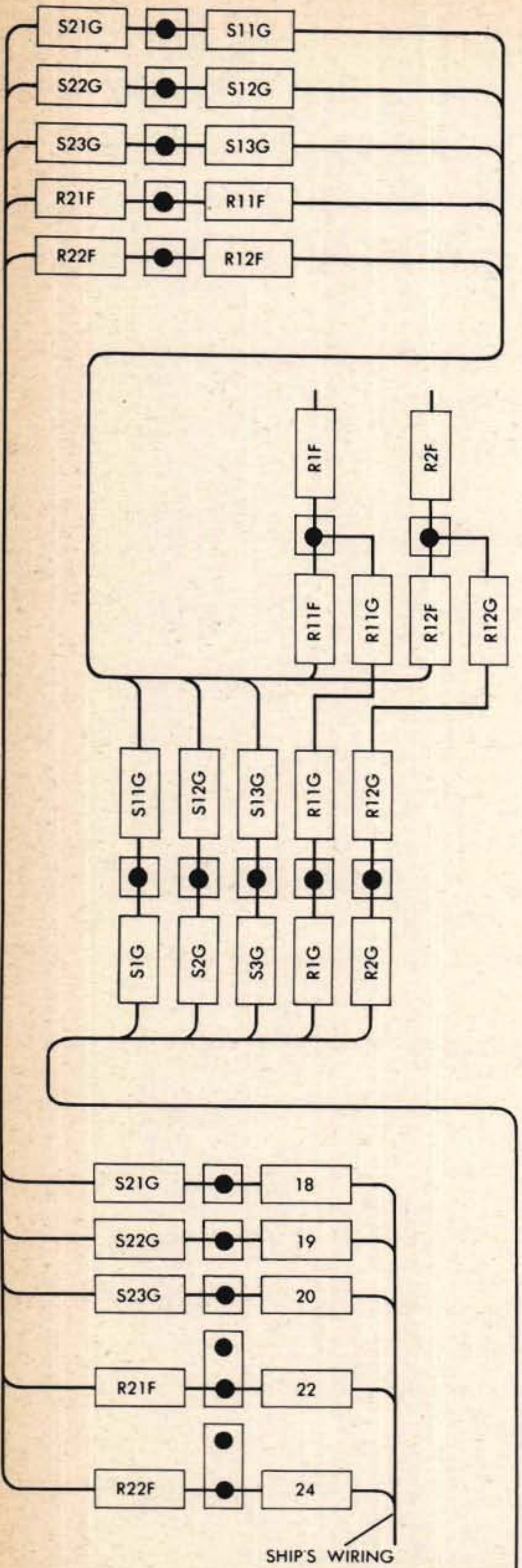
For servo motor circuits, each motor is assigned a letter (or a number and a letter), and the wires connected to the servo motor terminal block are assigned the same letter. For example, in the portion of the wiring diagram which appears on this page, H is the designation of the motor. The wire connected to the same bus bar on the motor terminal block as the pigtail wire leading to the center contact (3) is also designated H. The wire connected to the central stator lead (C) is designated HH.

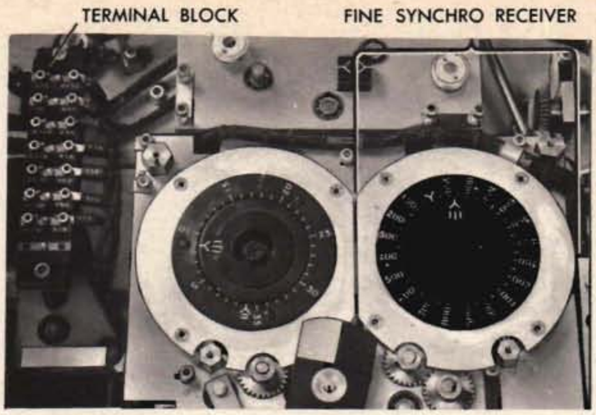
In the single-letter circuit, one (1) is added after the letter for each additional wire between the motor and one of the power supply terminal blocks (PS2). The designations then become H1 for the first additional wire and H2 for the second additional wire.

In the double-letter circuit, there is only one wire between the motor and a power supply block (PPS1), but if there had been additional wires, they would have been numbered as in the single-letter (HH1, HH2, etc.).



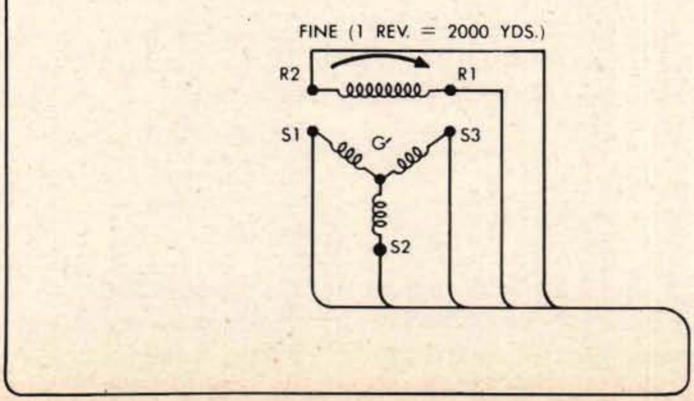






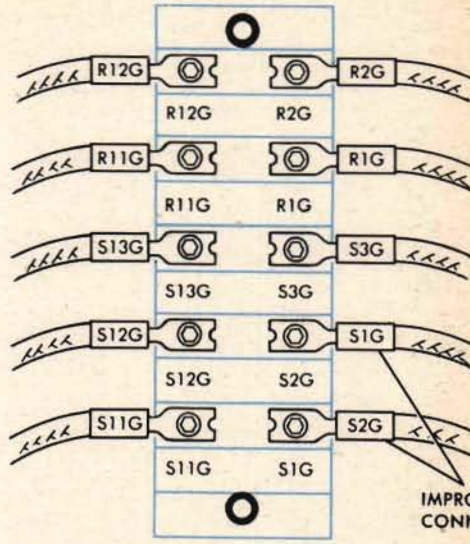
For synchro transmission circuits, one or two letters are assigned to each synchro. The individual wires are distinguished by the rotor and stator lead markings followed by this assigned letter. For example, in the portion of the wiring diagram shown here, the synchro motor is assigned the letter G. The stampings S1, S2, S3 (stator leads) and R1 and R2 (rotor leads) appear on the synchro itself to identify the leads. At the terminal block end, each of these lead designations is followed by the letter G which is assigned to the unit. Ten (10) is added to the number for each additional wire in the circuit. The designations then become S11G, S12G, etc. until the terminal block with the ship's wiring is reached. Note that in this particular case, the rotor leads of the G circuit are connected in common to the rotor leads of synchro unit F.

Besides identifying wires, the wiring diagram contains a wealth of additional information, such as: the switch position necessary to close a circuit; directions of increasing rotation; contact for increasing rotation; size and type of wire; and the names of units.



Trouble-shooting the instrument wiring

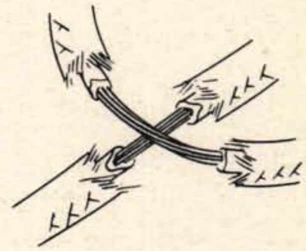
Trouble in the instrument wiring may be due to one of four causes: improper, short, open or grounded circuits. All the possibilities must be checked systematically, because there is no short-cut method of locating wiring trouble.



IMPROPER CONNECTION

Improper connection

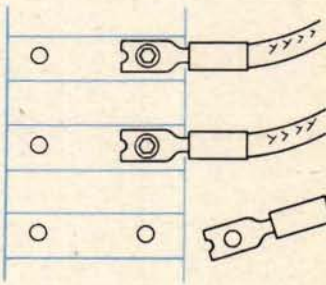
An improper connection occurs when a wire carrying current intended for one circuit energizes another circuit. An improper connection may be caused by a misplaced terminal on a bus bar, bare wires making contact, or a piece of foreign conducting material bridging two or more terminals.



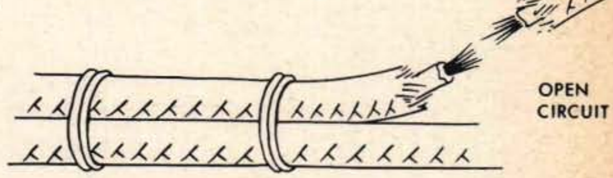
SHORT CIRCUIT

Short circuit

A short circuit occurs when the current is bypassed from one side of the supply to the other. Fuses of proper size should protect the equipment, but damage may result from the heat generated by the flow of excessive current through a short. A short circuit may be caused by crossed wires or an improper connection.



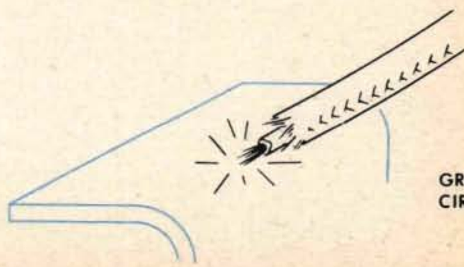
OPEN CIRCUIT



OPEN CIRCUIT

Open circuit

An open circuit is one having a break or gap. An open circuit may be caused by a loose or detached terminal, or by a broken wire.

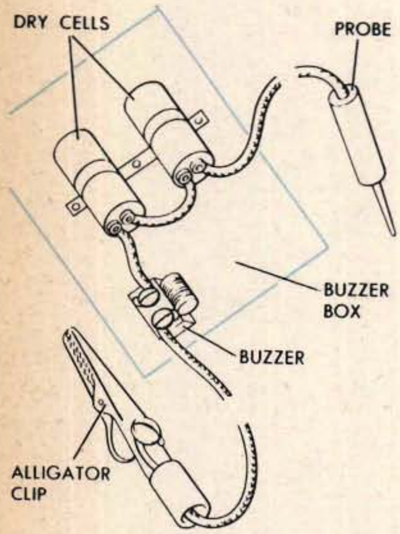


GROUNDED CIRCUIT

Grounded circuit

A wire is considered grounded if it touches the case or plates of an instrument. Damage occurs only when the grounded wire makes a circuit to the other side of the supply line.

Buzzing through a circuit



One of the instruments used for checking the continuity of a circuit is the "buzzer box." The power switch should be OFF when the buzzer is used.

1 Use the wiring diagram to locate both ends of the circuit to be tested. Check that the designations are correct.

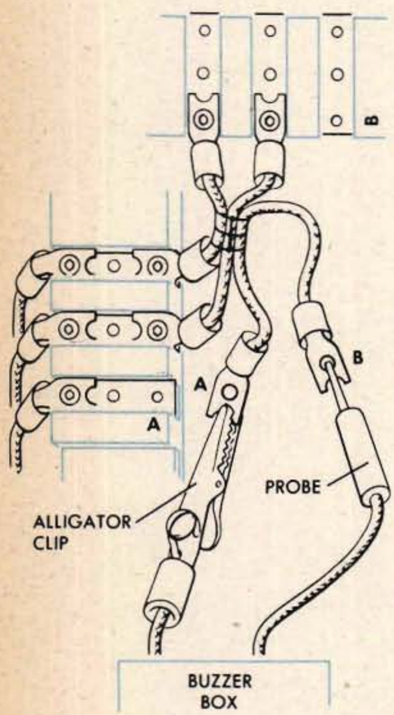
2 Position all switches and contacts in the circuit so that they close the circuit.

3 Disconnect the wires at the terminal blocks that energize the circuit.

4 Connect one of the leads from the buzzer box to one of these terminals.

5 Tap the other buzzer box lead to the other terminal. The buzzer will sound if the circuit is completed. A probe facilitates buzzing if there are no bare terminals. Use it to puncture the insulation and touch the wire.

Unless there is a resistor or a high-resistance winding in the circuit, a silent buzzer indicates that there is an open circuit. Use an ohmmeter to check a resistor or a high-resistance winding.



Locating the trouble

In short circuits and improper connections, tap one of the buzzer leads against the terminals of adjacent wires. Look for signs of melted copper and scorched insulation; these signs sometimes accompany shorts.

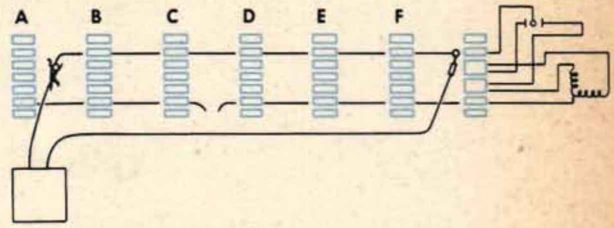
Sounding of the buzzer when one of the buzzer leads is tapped against the case of the instrument indicates that the circuit is grounded. The insulation resistance can be measured with a Megger as a further and more precise check.

Isolate the source of trouble by a method similar to that for locating the break in an open circuit.

Locating the break in an open circuit

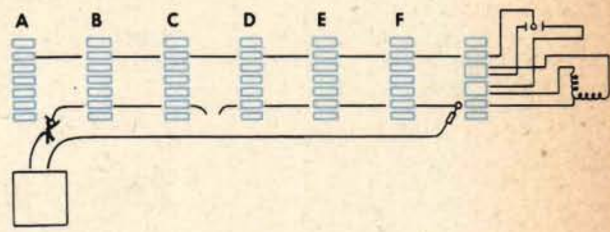
1 Test the portions of the circuit where the break is suspected. Sounding of the buzzer indicates a continuous circuit.

BUZZER SOUNDS
CIRCUIT COMPLETED

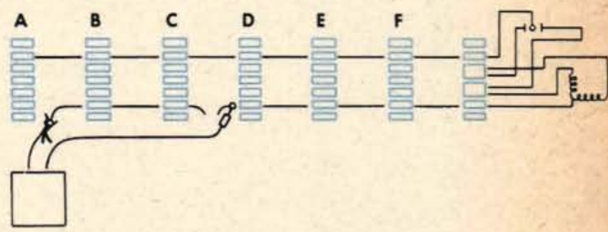


2 When the buzzer does not sound, the portion of the circuit with the break has been found.

BUZZER DOES NOT SOUND
CIRCUIT NOT COMPLETED

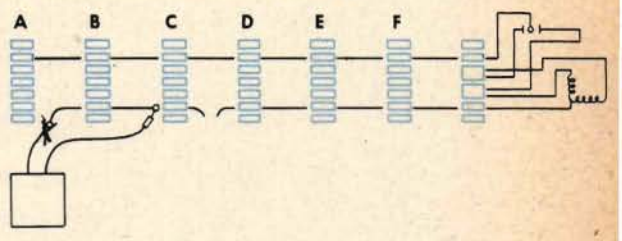


BUZZER DOES NOT SOUND
CIRCUIT NOT COMPLETED



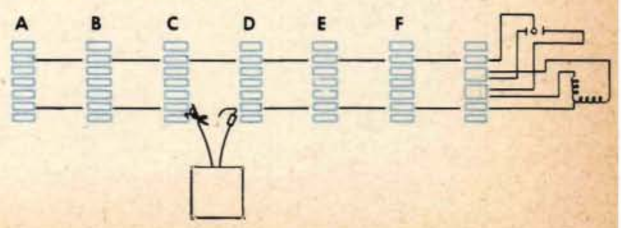
3 Narrow the broken portion down until the buzzer sounds.

BUZZER SOUNDS
THEREFORE CIRCUIT BROKEN
IN WIRE BETWEEN BLOCKS **C** AND **D**



4 Verify the location of the break, by making contact on the ends of the wire in question.

VERIFICATION
BUZZER DOES NOT SOUND



Repair procedure

When the source of wiring trouble has been located, make the necessary replacement, using the same size and kind of wire as used for the original connection.

Types of wire

Two sizes of stranded wire, made according to Navy Specifications, are used for instrument wiring. The size and type is noted on the wiring diagram. The lighter type is used between units and the heavier for power-supply circuits. In addition, pigtail wiring is used where great flexibility is required.

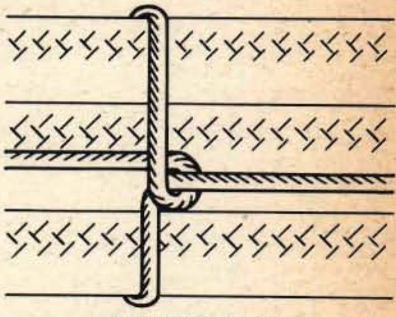
Replacing a wire

A broken wire or one with damaged insulation should be replaced. Whenever possible, replace only ONE wire at a time to avoid making an improper connection.

1. Remove wire terminals from the bus bars on the terminal blocks.
2. Clip the terminals from the old wire to remove the identification tags or sleeves.
3. Cut a new length of the same type of wire slightly longer than the piece to be replaced.
4. If possible, remove the damaged wire. If the wire cannot be removed, tape the ends. Where possible clip the lacing, bend the new wire so that it follows the same course as the old wire, and relace. Keep the wiring neat.
5. With the new wire in place, cut the ends to proper length by matching them to their bus bars on the terminal blocks.
6. Remove the insulation from the ends of the wire.
7. Slip the identification tags over the ends of the new wire.
8. Solder or crimp new terminals to the ends of the wire.
9. Clean the flat faces of the terminals.
10. Attach the terminals to the proper bus bars on the terminal blocks.

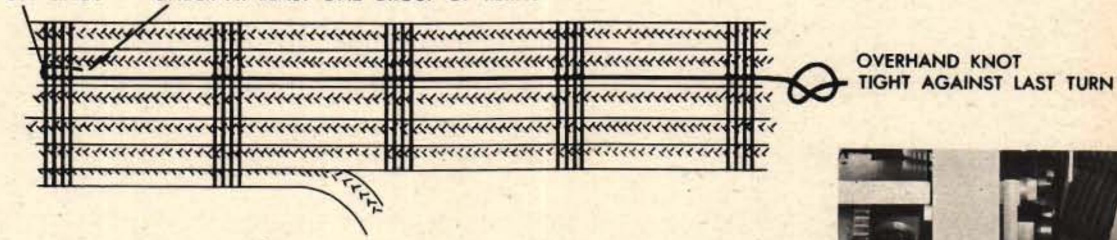
Binding a cable

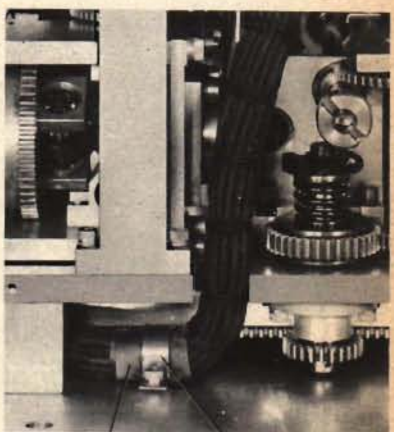
Since individual wires are likely to sag and catch in adjacent mechanisms, they are always bound or laced together in a cable where two or more follow the same path. Waxed cotton cord is used for binding. Before binding is begun, all wires must be parallel. Apply the cord as shown in the accompanying sketch, using only the regulation cableman's knot. Draw each knot tight before proceeding to the next. The table shows the number of turns of cord to be used in each group and the spaces between groups in binding wires into a cable.



CABLEMAN'S KNOT

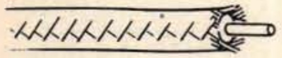
Number of wires	Number of turns	Spacing
from 2 to 4	1	1″
5 to 15	2	1″
16 to 25	3	¾″
26 to 35	4	¾″
36 to 75	5	¾″



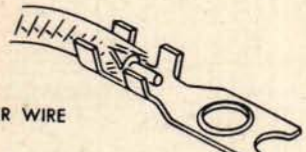


After binding a cable, secure it in place with wire clamps. Place fish paper, a tough insulating material, between the cable and the clamp, unless the wires are shielded. Use the clamps on shielded wire cables as intermediate grounds. In either case, the clamp should hold the cable firmly in place, but without cutting into the insulation.

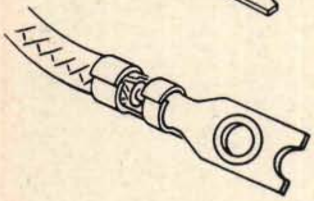
REMOVE INSULATION



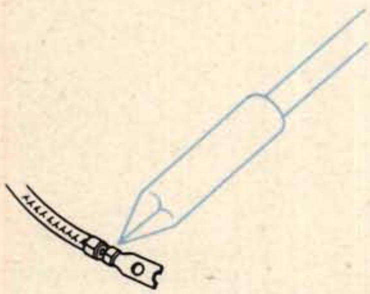
PLACE WIRE IN GROOVE



FOLD LUGS OVER WIRE



SOLDER



Attaching soldered terminals

1 Remove about ⅛ inch of insulation from the end of the wire, being careful not to cut or nick individual strands of the wire.

2 Using a rosin-type flux, tin the exposed end of the wire.

3 Place the tinned wire between the lugs of the terminal, with the longer lugs at the insulation and the shorter lugs at the bare wire.

4 Fold the long lugs tightly over the insulation and the short lugs over the wire.

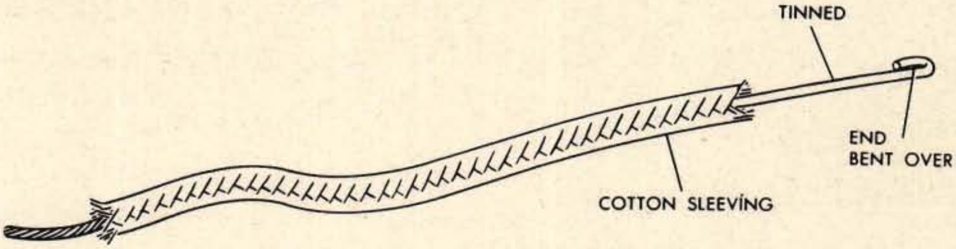
5 Heat the short lugs. Add a drop of solder.

6 Using a cloth dampened with alcohol, wipe excess flux from the surface.

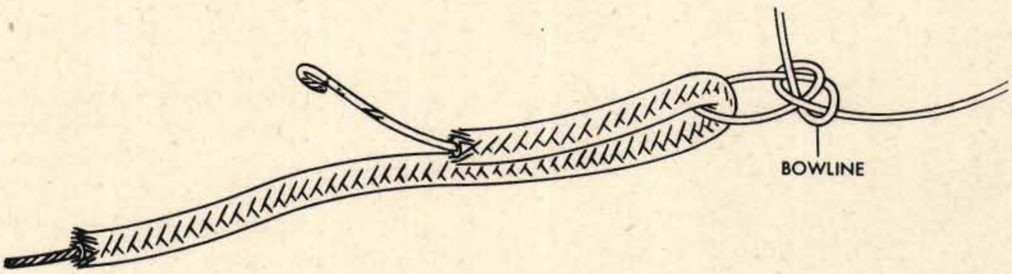
Repairing pigtail wiring

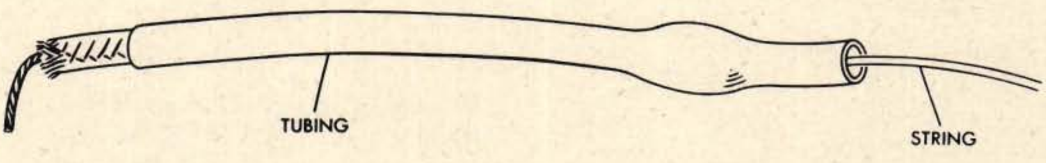
Pigtail wiring is used where great flexibility is desired. It consists of a lightly twisted strand of very fine copper wires threaded through cotton sleeving. Where pigtail wires are bound into a cable and clamped to the unit, no flexibility is required. The pigtails are then run through extruded plastic tubing to prevent shorts and grounds. Before repairs can be made, it may be necessary not only to cut the binding but to remove the entire pigtail cable. More skill is required to repair pigtail wiring than to repair ordinary wiring.

To thread a strand of pigtail wire through the cotton sleeving, tin the strand for two inches for stiffness, and bend the end over so that it will slip smoothly through the sleeving.



To thread the wire and the sleeving through the tubing, tie a bowline at one end of a string slightly longer than the tubing and pass the other end of the string through the tubing. Loop one end of the pigtail in the bowline. Pull the wire through the tubing.

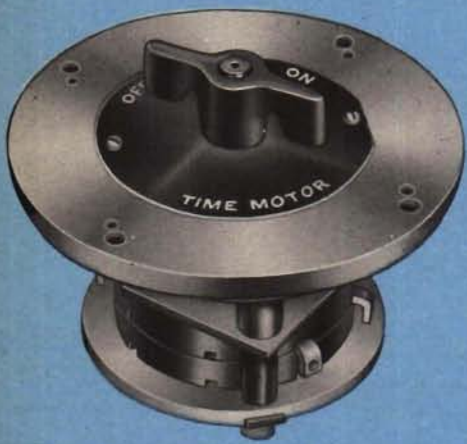




In order to avoid burning or charring the cotton sleeving when soldering pigtail wiring, do not heat the iron any more than is necessary to do the job. Do not allow solder to run back along the thin wire, because it will make the wire stiff. Also, be very careful not to break any of the fine wires. Broken wires may pierce the cotton sleeving, become grounded, cause a short circuit and burn out the lead.

SWITCHES

There are three main types of switches: rotary, push-button, and leaf-spring.



A ROTARY SWITCH

A *rotary switch* is operated by turning a handle attached to the shaft of the switch.

A PUSH-BUTTON SWITCH

A *push-button switch* is usually located under a handcrank. When the handcrank is put in the IN position, the switch-actuating screw at the end of the shaft presses against the push-button and opens the circuit.

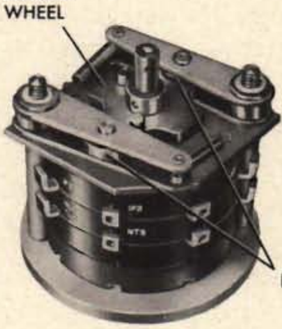
A LEAF-SPRING SWITCH

A *leaf-spring switch* is usually actuated by a push-button on the cover of the instrument. Pressing the push-button closes the circuit.

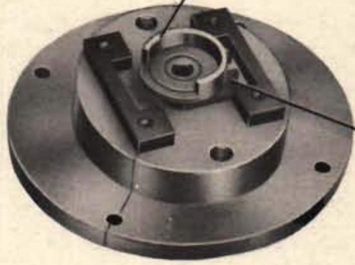
Any of these switches can be removed from the instrument by disconnecting the leads and taking out the mounting screws.

Rotary switches

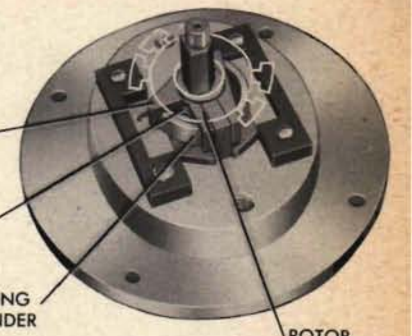
Two types of rotary switches are discussed in this chapter, the direct-action type and the delayed-action type.



DIRECT-ACTION TYPE
TOP PLATE REMOVED



DELAYED-ACTION TYPE
UNDERSIDE OF TOP PLATE



The direct-action type is controlled by a regular detent mechanism, which is like the detent described in the chapter on shaft line devices, page 124.

The delayed-action type is somewhat more complicated. This is how it works.

Turning the handle rotates the spring winder, which winds the strong coil spring against the spring support.

Simultaneously, the eccentric pulls the pawl, which is detained between the two bars, in toward the center.

The pawl acts as a trigger. When it clears the corner of a bar, the spring unwinds with a snap, and the spring support, the rotor, and the pawl jump one quarter of a turn to a new position.

The almost instantaneous opening of circuits that results from the snapping action of this switch minimizes arcing. For this reason, the POWER switch usually is a delayed-action type of switch.

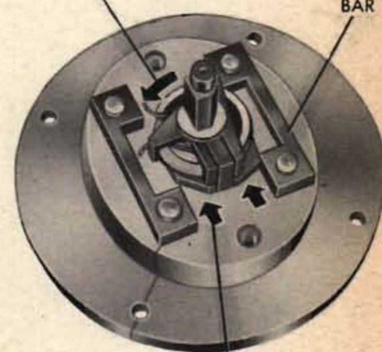
If a switch does not operate properly, look for one of the following symptoms:

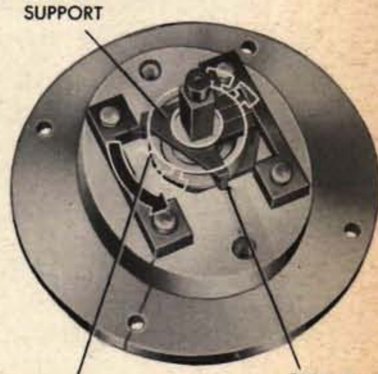
JAMMING: The handle or the push-button cannot be moved.

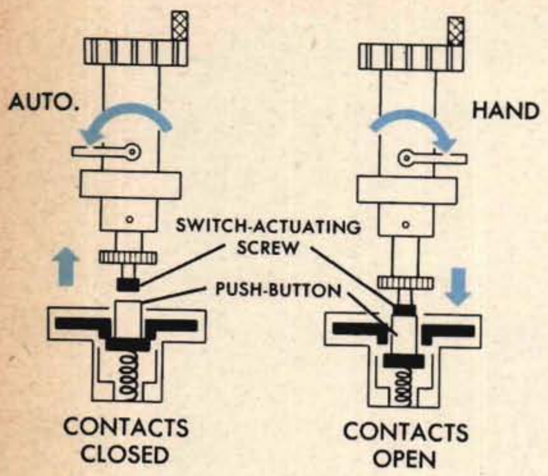
STICKING: The handle or the push-button operates with difficulty.

SLIPPING: In a rotary switch, there is no feeling of detent action when the handle is turned.

ELECTRICAL TROUBLE: The contacts fail to close the circuit when they are brought together.



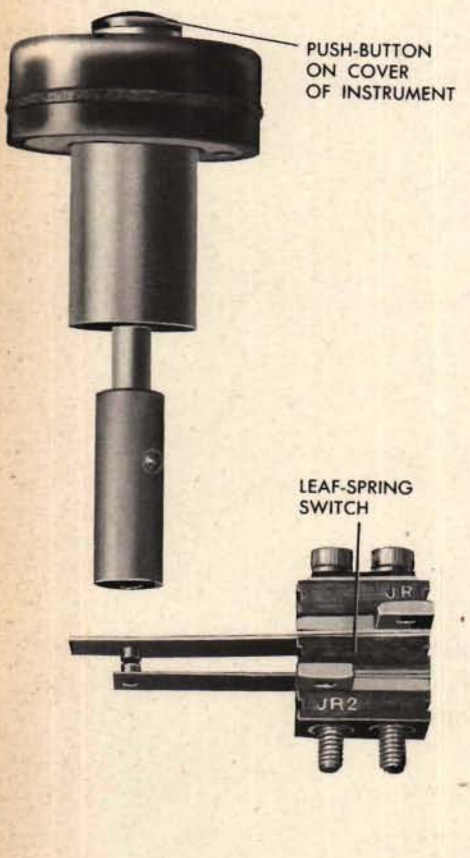




Locating the cause

In locating the cause of trouble in a push-button switch, first check the setting of the handcrank switch-actuating screw that depresses the button.

In locating the cause of trouble in a leaf-spring switch, first check the operation of the push-button that presses the contacts together.

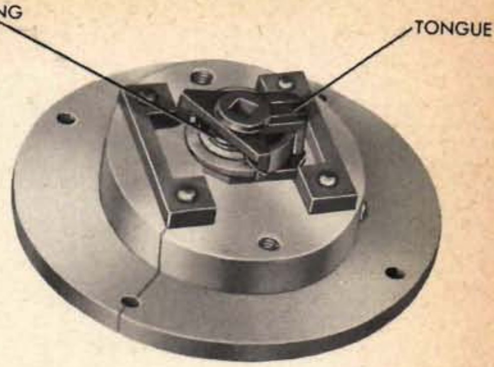


Jamming or sticking

In either type of rotary switch, jamming or sticking may be caused by a dirty or damaged bearing on the shaft which supports the rotor, or by bent contacts. Also, if one of the screws which hold the switch together is loose, the bakelite sections may tilt and permit the rotor contacts to jam against the terminal contacts inside the switch.

A casualty in the detent of a direct-action type may result in jamming or sticking.

In the delayed-action type, the rivets holding the bars to the plate may become loose, permitting the pawl to jam against the bar, or a dirty or damaged eccentric may jam or stick in the pawl.

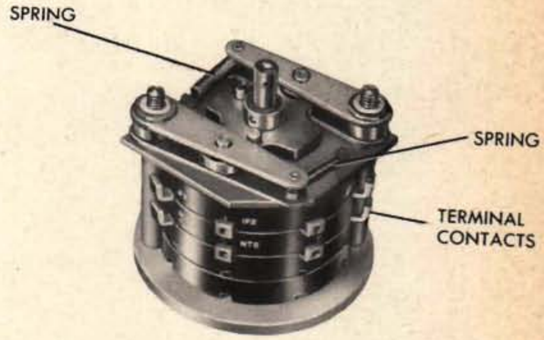


DELAYED-ACTION ROTARY SWITCH

Slipping

In the delayed-action type, a broken spring or a broken tongue on the spring support may not only prevent the switch from snapping to a new position when the handle is turned, but may prevent it from staying in any one position.

Likewise, in the direct-action type, if a spring on one of the follower arms becomes unhooked or damaged, the detent probably will not operate properly; the handle will turn freely, but the detent will not hold the rotor in position.



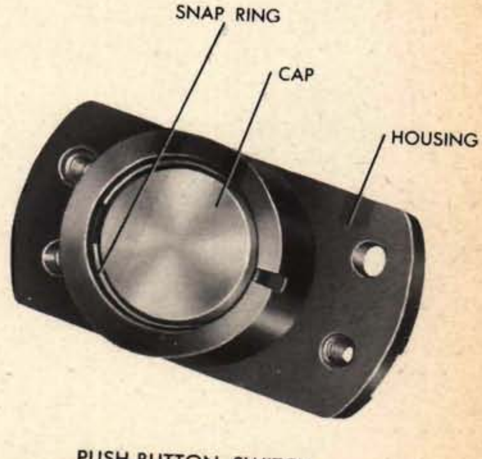
DIRECT-ACTION ROTARY SWITCH

Electrical trouble

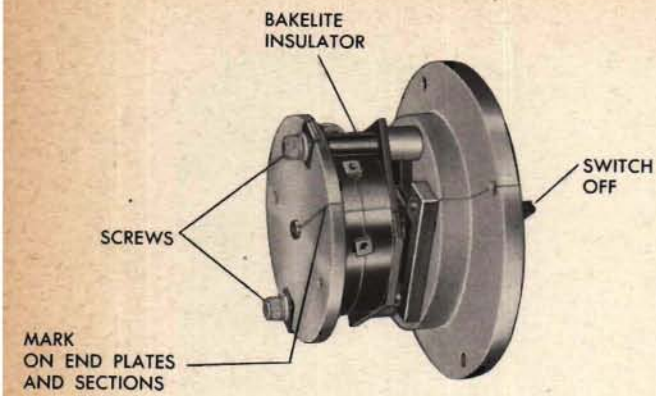
Dirty, damaged, or broken contacts may cause electrical failure in any of the switches.

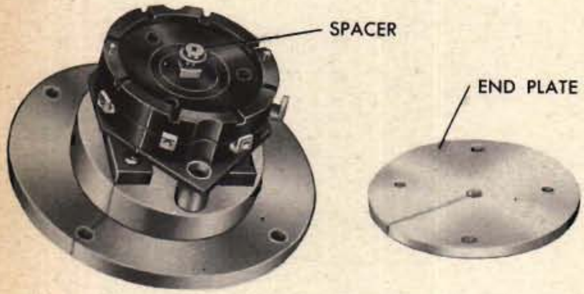
In the push-button switch, the button may be pushed down so far by the switch-actuating screw on the handcrank that the cap, spring, and button are forced out of the housing.

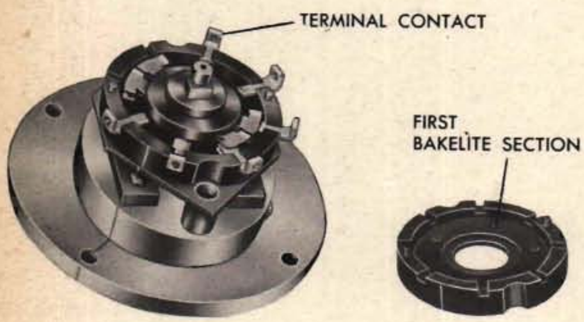
To locate the cause of electrical trouble in a switch, refer to the wiring diagram to trace the circuits. Use a buzzer, or a similar device, to test the circuits and locate the contacts which have failed.

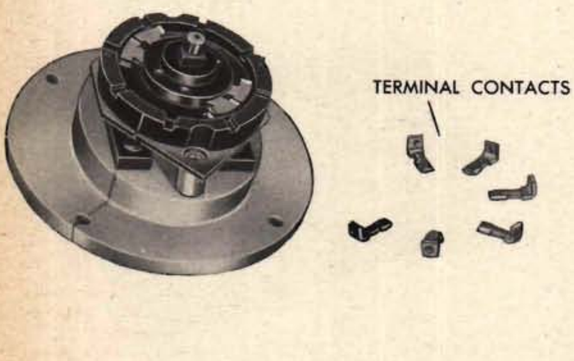


PUSH-BUTTON SWITCH (BOTTOM VIEW)









Disassembling switches

In preparing to disassemble any switch, disconnect the leads and remove the screws that hold the switch in the instrument. It may be necessary also to remove the handle, the handle adapter, or other mechanical connection.

Disassembling the rotary switch

The disassembly procedure is practically the same for either type of rotary switch. The instructions that follow cover the delayed-action type, which is slightly more complex than the direct-action type.

1 Set the switch handle at the OFF position and mark the relationship between the end plates and the bakelite sections, as illustrated.

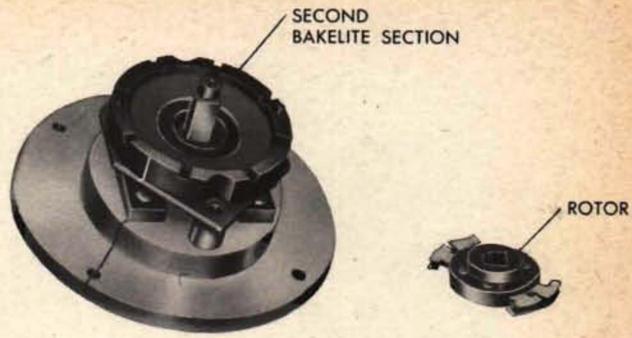
2 Remove the two long screws holding the switch together. (The two bakelite insulators will fall off.)

3 Remove the end plate from the switch and the spacer from its shaft. Tag the spacer.

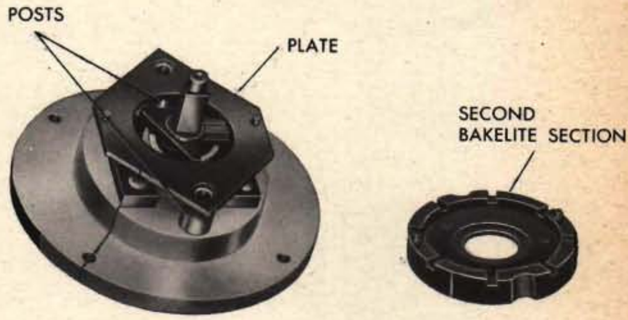
4 Lift off the first bakelite section.

5 Remove the terminal contacts. As an aid to correct reassembly, make a sketch to show the relationship of the terminal contacts to the mark made in step 1.

6 Remove the rotor.

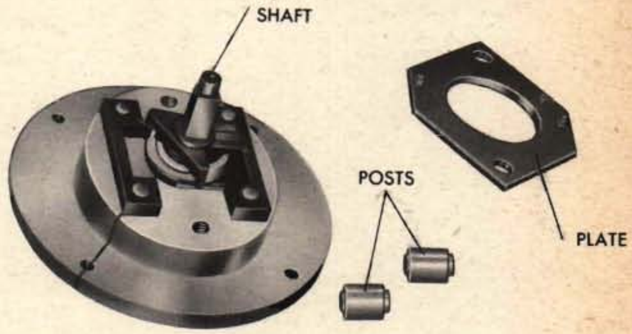


7 Remove the second bakelite section.

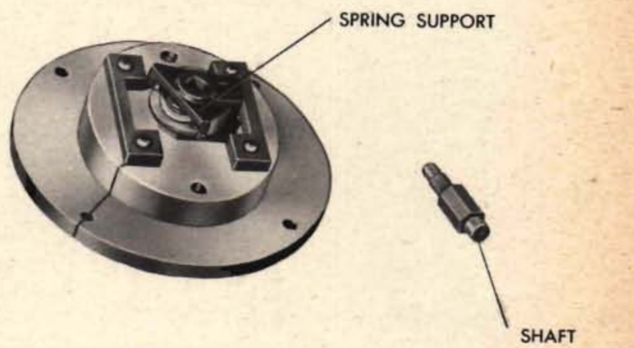


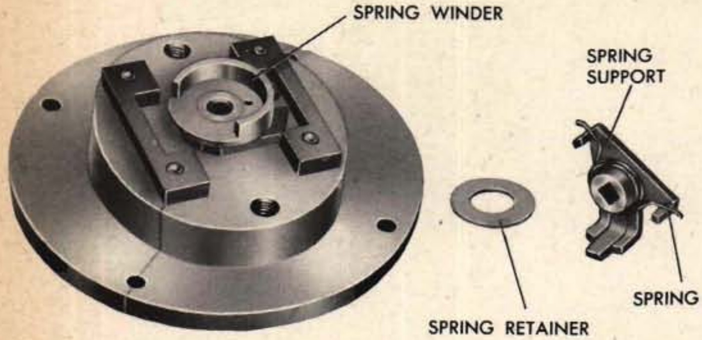
8 Lift off the metal plate.

9 Remove the two posts from the housing.



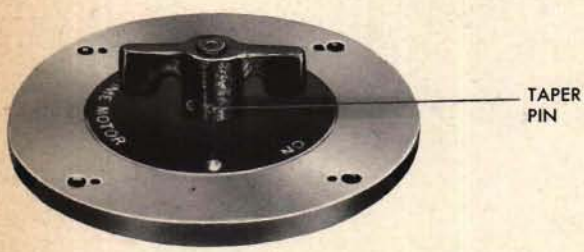
10 Lift out the shaft.



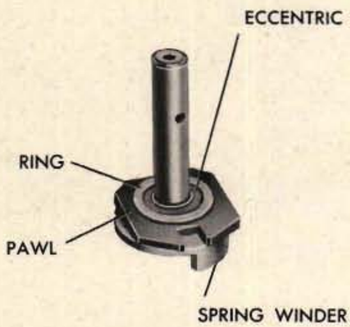


11 Remove the spring support and spring. Separate the spring from the support.

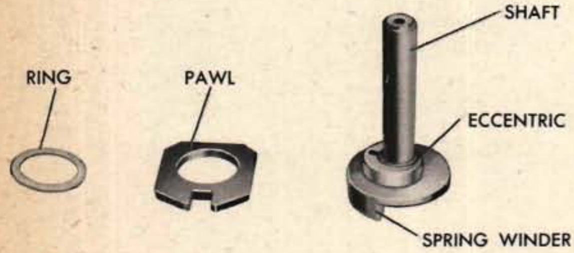
12 Pick up the spring retainer in the spring winder.



13 Drive the taper pin out of the handle and take the handle off its shaft.



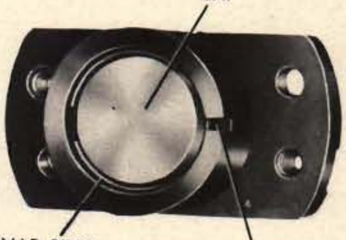
14 Pull the spring-winder assembly out of the front plate.



15 Supporting the spring winder on the pawl, drive the ring off the eccentric by tapping on the shaft.

Disassembling the push-button switch

1 Remove the insulating spacer from the housing.



2 Take out the snap ring by pressing the cap down and inserting a tool in the slot of the housing.

3 Remove the cap and the coil spring.

4 Lift out the push-button.

Repairing the parts

All switches

Replace a spring or any part that has been broken.

The rotary switch

Clean dirty contact surfaces with an approved solvent. Polish pitted contact surfaces with a fine abrasive paper or a fine oil stone.

Lubricate (with an approved lubricant) the terminal contacts after they have been cleaned.

Straighten a bent shaft according to the instructions in *Basic Repair Operations,* page 69.

Clean and polish a shaft that binds in a plate.

Clean dirty ball bearings with an approved solvent. Replace damaged bearings.

Rerivet a loose bar in the delayed-action switch. Position it according to the assembly drawing.

In the multiple switch, stone a burred detent wheel.

The push-button switch

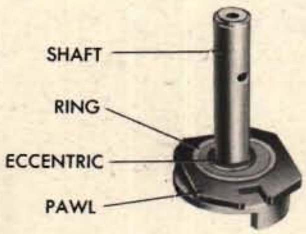
If the housing or a contact is damaged, replace the entire switch.

Reassembling switches

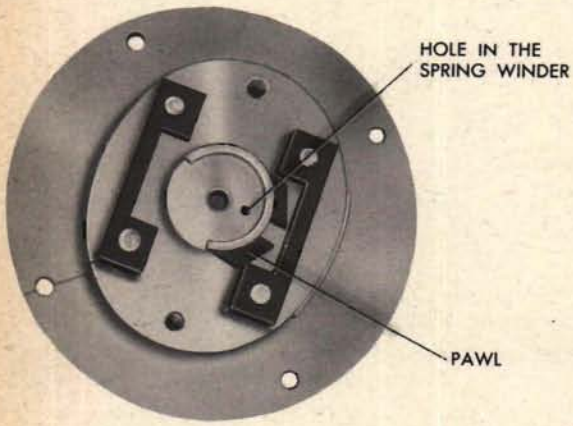
Wash all the parts with an approved solvent and dry them before reassembly. Use an approved lubricant on all the moving parts.

Refer to the assembly drawing for guidance in the reassembly procedure.

Reassembling the rotary switch



1 Place the pawl over the eccentric, and the ring over the pawl. Stake the ring and check that the pawl turns freely on the eccentric.

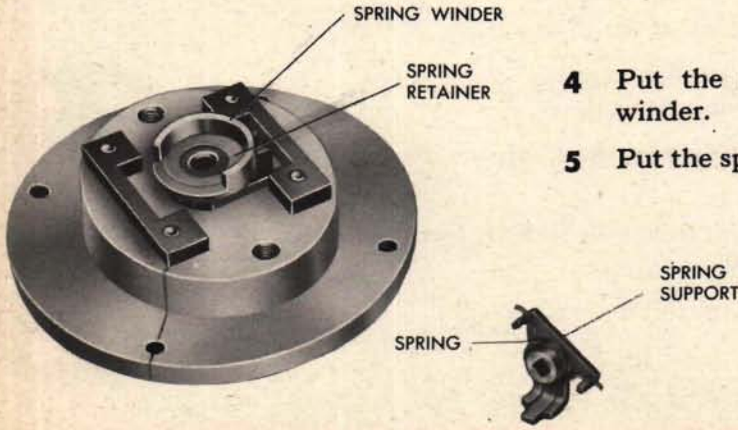


2 Put the shaft through the front plate.

3 Pin the handle to the shaft.

NOTE.

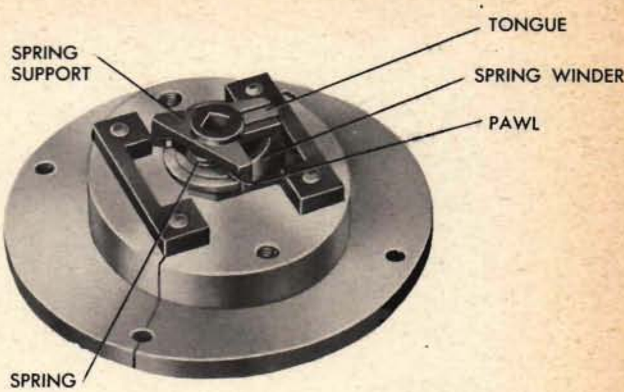
In the steps which follow, keep the hole in the spring winder over the slot in the pawl.



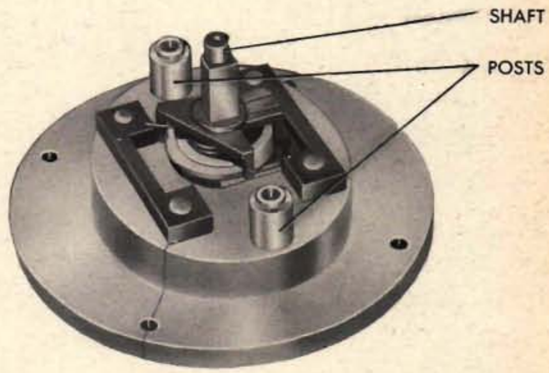
4 Put the spring retainer in the spring winder.

5 Put the spring in the spring support.

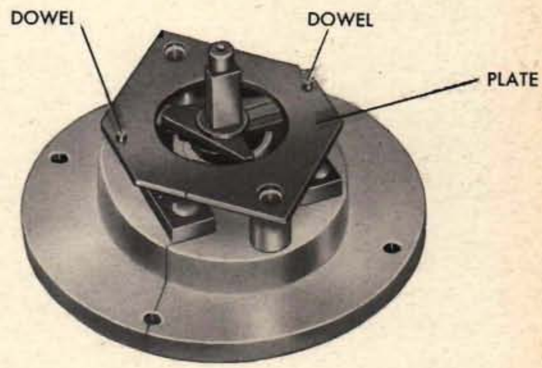
6 Mount the spring support on the spring winder. The tongue of the support fits into the slot in the pawl.



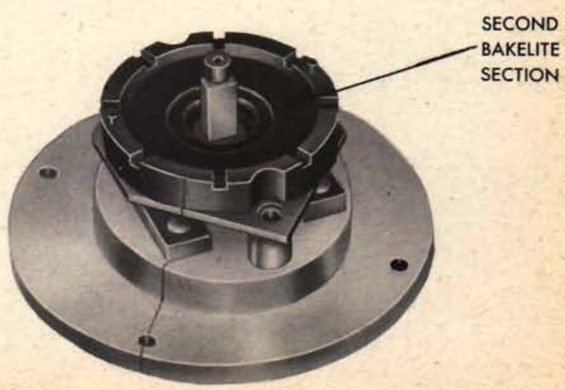
7 Place the square end of the shaft in the hole of the spring support.



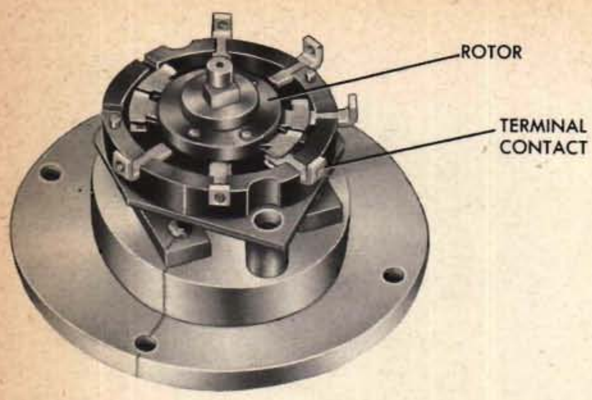
8 Mount the posts with their small shoulders down.



9 Mount the plate on the posts with the dowels up, aligning the mark on it with the mark on the front plate.

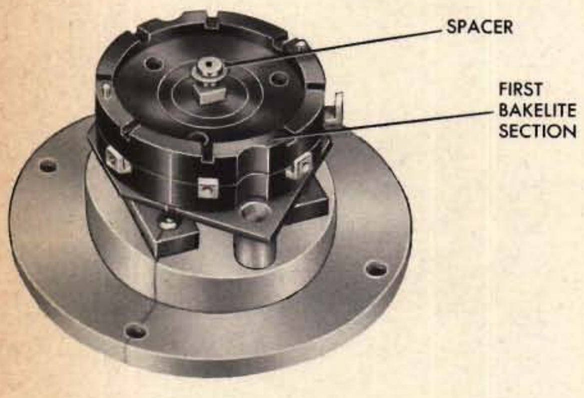


10 Mount the second bakelite section.



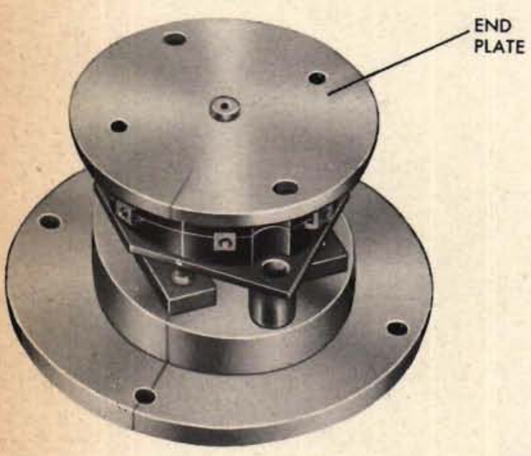
11 Mount the rotor.

12 Put the terminal contacts in place. Lubricate them lightly with an approved lubricant.

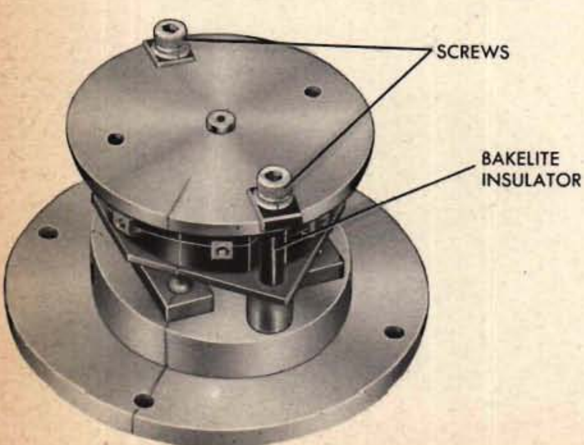


13 Mount the first bakelite section.

14 Place the spacer on the shaft.



15 Mount the end plate.

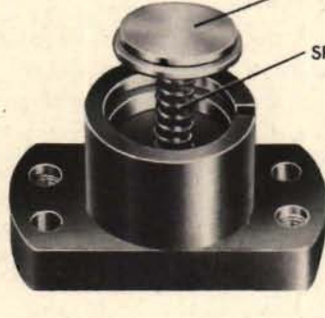


16 Hold the bakelite insulators between the plates and fasten the assembly together with the two long screws.

Reassembling the push-button switch

1 Put the push-button in the housing.

2 Insert the coil spring with the cap on top of it.



3 Put the snap ring in place.

4 Put the insulating spacer in place.

Bench checking the unit

All switches

Check for continuity. The contacts must open and close properly when the switch is operated.

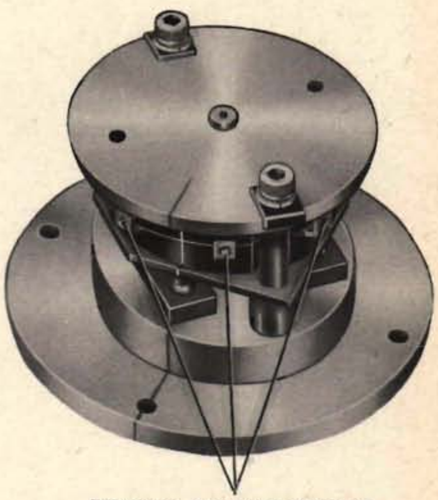
Rotary switches

1 Check the switch with the assembly drawing and the instrument wiring diagram.

2 The switch must operate freely, but with positive detent action.

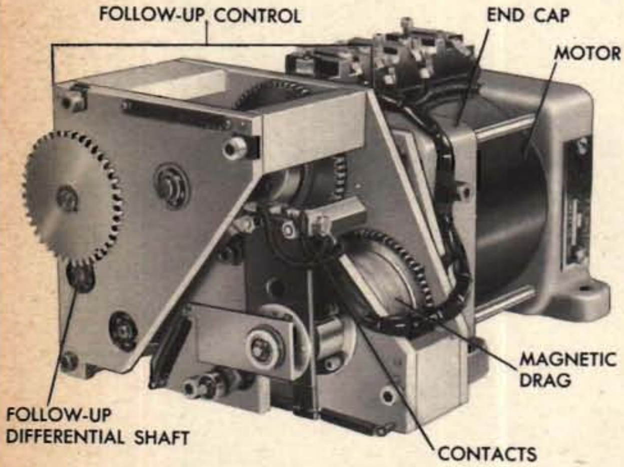
3 The threads in the terminal contacts should be checked for damage. (They usually are tapped for No. 6-32 machine screws.)

4 The handle position must agree with the circuits connected.



THE FOLLOW-UP

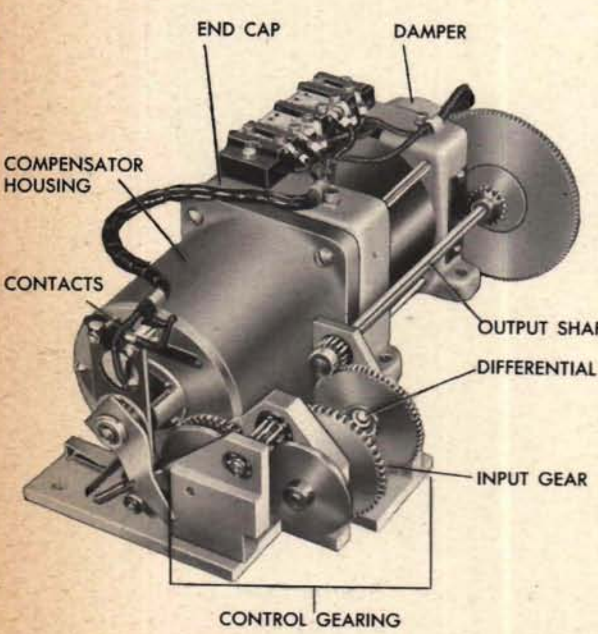
The types of follow-ups described in this chapter are electromechanical devices for amplifying the motion and power of shaft lines. They consist of a follow-up control, a motor, the wiring connecting the control with the motor, and a capacitor connected with the motor. In addition, a damper is usually provided.



A MAGNETIC DRAG FOLLOW-UP

In all the controls covered in this chapter, the contacts are actuated by intermittent gearing driven by the output of a differential. This differential, called the follow-up differential, compares the input with the response from the output of the follow-up.

The name of a follow-up is usually derived from some conspicuous feature in the design of the follow-up control.



A COMPENSATED FOLLOW-UP

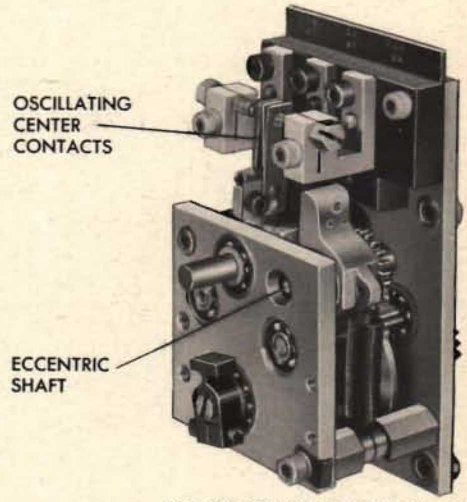
The MAGNETIC DRAG FOLLOW-UP, sometimes called the velocity-lag type, features a magnetic drag in the control. The entire control, consisting of the differential, the output gearing, the intermittent gearing, the contacts, and the magnetic drag, is contained in a framework mounted directly on one end cap of the motor. The follow-up can be removed from the instrument as one unit.

The COMPENSATED FOLLOW-UP, sometimes called the acceleration-lag follow-up, features a compensator which is enclosed in a housing attached to one end cap of the motor. The contacts are mounted on the compensator housing. The control gearing, consisting of the differential, the motor output gearing, and the intermittent gearing are mounted separately on a plate.

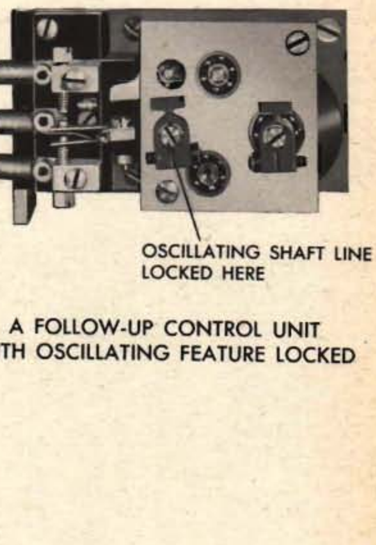
The OSCILLATING FOLLOW-UP features oscillating center contacts. The component parts of an oscillating follow-up are separated in the instrument. The control unit, consisting of the intermittent gearing, the contacts, the signal cam and the eccentric shaft which causes the center contacts to oscillate, is contained in a gear box which can be removed easily as one unit. The differential, motor, and control unit are connected by shaft lines. The contacts in this follow-up control are oscillated to reduce contact "dead space." In some forms of this follow-up, the oscillating feature is omitted or locked.

All these follow-ups, while different in construction, can develop the same general troubles because they operate on similar principles.

Some minor repair work may be done on follow-ups while they are mounted in the instrument. Because foreign matter may fall into other units if repairs are made in place, always cover the adjacent units well. If it is necessary to remove a follow-up from the instrument, consult the instrument instruction book.



AN OSCILLATING FOLLOW-UP CONTROL UNIT



A FOLLOW-UP CONTROL UNIT WITH OSCILLATING FEATURE LOCKED

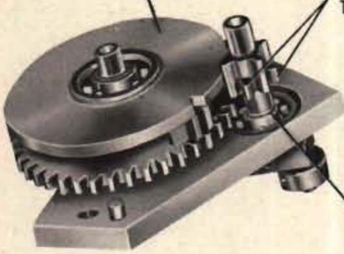
Typical symptoms

If tests indicate that a follow-up is not operating properly, even though 115-volt 60-cycle A.C. is brought to the terminal block, look for one of the following typical symptoms:

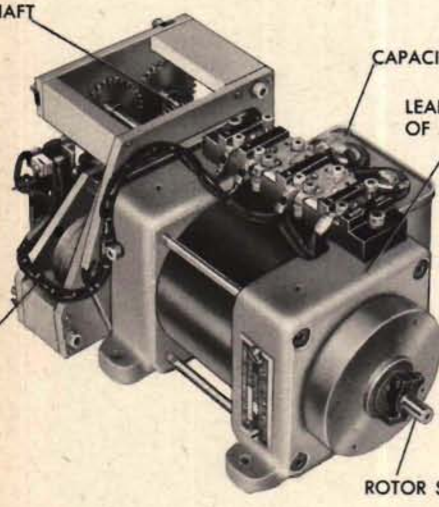
- Failure to run
- Running away
- Slipping
- Rough output
- Sluggishness
- Excessive oscillation

Locating the cause

Failure to run



OUTER PLATE, COMPENSATED FOLLOW-UP CONTROL GEARING



Failure of a follow-up to run may be due to a mechanical or an electrical cause.

Jammed gearing may prevent the follow-up from operating. If only the output shaft line is jammed, the input gearing, including the intermittent gearing, will be free to turn, and vice versa. If neither the input nor the output shaft line is free to turn, probably the differential spider is jammed. Locate the source of trouble by using the methods in the chapter *Shaft Lines,* page 92.

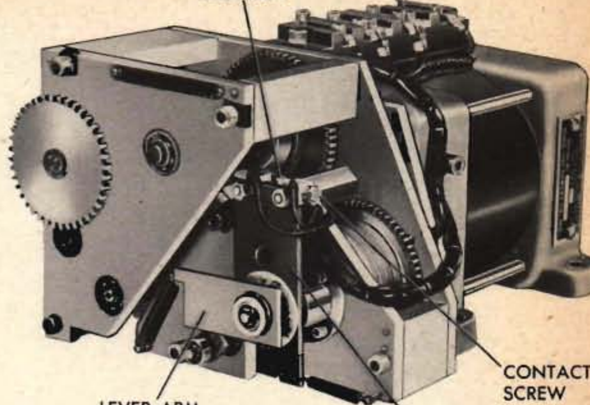
A locking disk may jam on the ends of cutaway teeth of an intermittent pinion if spacers were improperly replaced at reassembly.

Electrical failure may be the result of an open connection, such as a break in the wiring, dirty contact surfaces, a faulty capacitor, or a common connection between L and R.

With the power ON, try turning the rotor. If it is absolutely free to turn, the trouble probably is an open circuit. Turn the power OFF and disconnect the incoming, *single-letter* lead. Turn the power ON and touch this lead to the bus bar marked L (or 2) in order to by-pass the contacts. This should cause the motor to run counterclockwise (viewed from the lead end). Shifting the lead to the bus bar marked R (or 1) should cause the motor to run clockwise.

CAUTION:
Do not allow the single-letter lead to touch the double-letter bus bar (also marked C). This would be a short circuit, and damage might result.

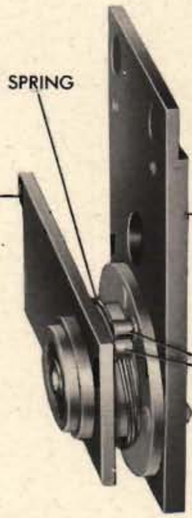
If the motor runs after the contacts are by-passed, probably the open is in the pigtail wiring leading to the contacts. If the motor is still stalled after the contacts are by-passed, there may be an open between the terminal block and the motor windings, or in the motor windings themselves. If the motor runs, but slowly, after being given a start, probably the capacitor is faulty. Turn the power OFF and replace the capacitor with a new one. Turn the power ON again and recheck the rotor torque.



If the rotor slightly resists turning, probably L and R are connected in common. This is often caused by the contact gap being closed completely.

Runaway follow-up

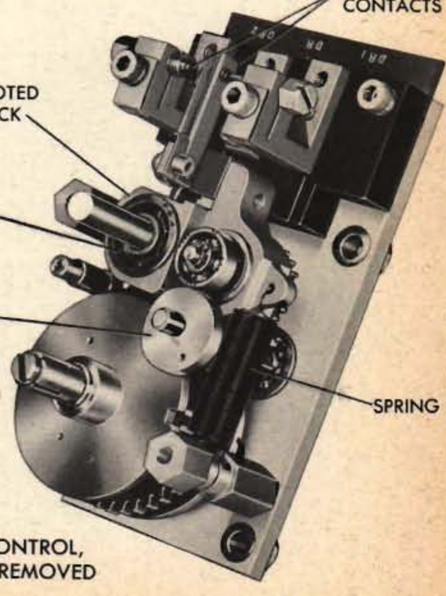
A follow-up running continuously in one direction, or until it runs into its limit stop, indicates a constant connection between the center and one of the outside contacts. This may be caused by improperly connected wires between the contacts and the terminal block in any type of follow-up.



OUTSIDE CONTACT-ARM ASSEMBLY, MAGNETIC DRAG FOLLOW-UP

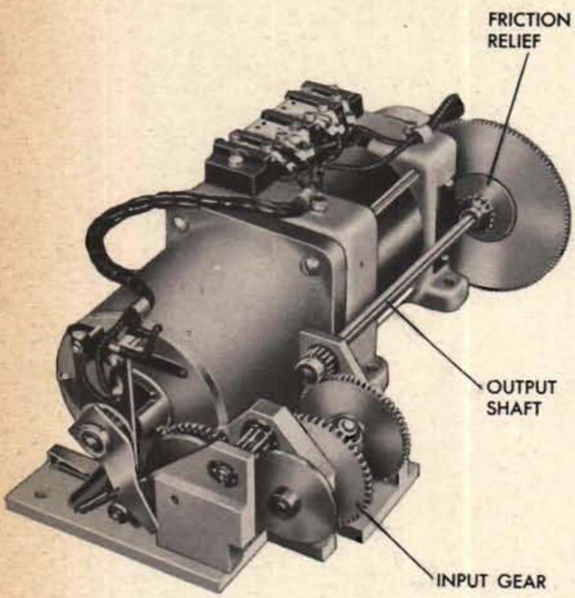
In the magnetic drag and compensated follow-up controls, a constant connection between the center and one of the outside contacts may occur because of a jammed plain bearing between the lever arm and outside contact arm, which prevents the coil relief spring from returning the outside contact arm to its normal position with respect to the lever arm. The outside contact arm is in the normal position when the pins are together.

A constant connection also may occur if the pigtails are entangled, pulling the contacts over in one direction; if one of the centering springs is unhooked, broken or stretched, permitting the other spring to pull the center contact over; or if the center contact has been bent out of shape.



OSCILLATING FOLLOW-UP CONTROL, FRONT PLATE REMOVED

Casualties to the securely mounted outside contacts in the oscillating follow-up are infrequent. However, if the bearing for the pivoted block is sticky, or if the spring holding the pivoted block against the signal cam is stretched or damaged, the center contacts may bear against one of the outside contacts continuously, causing the follow-up to "run away."



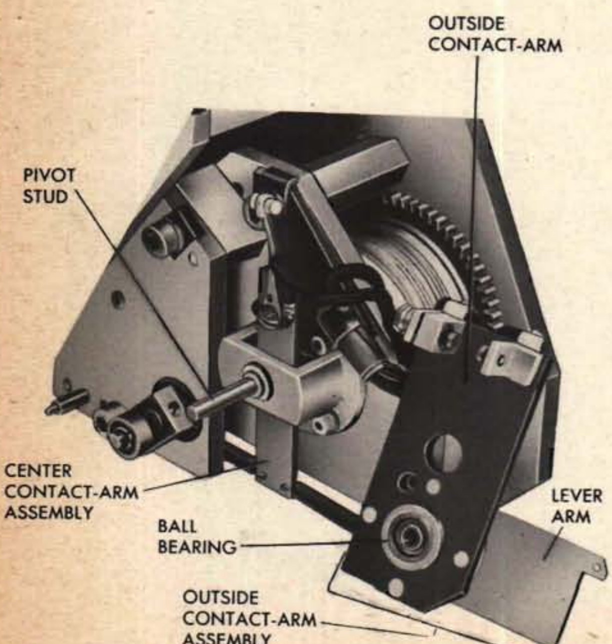
Slipping

A follow-up is said to be slipping if the motor runs but the output shaft does not turn in exact proportion to the input shaft. Examine the shaft lines for sheared or missing taper pins and for loose clamps. Locate the source of slipping by the methods described on page 103.

Slipping of a different nature results from a loose friction relief. Looseness of a friction affects the torque available for turning the output shaft line. The output may turn slowly or not at all even though the motor rotor turns. If the output turns at all, the follow-up will synchronize eventually, and the values of the input and output shafts will agree. Instructions for adjusting a friction relief are given on page 436. Data for setting friction torque are given on the follow-up assembly drawing.

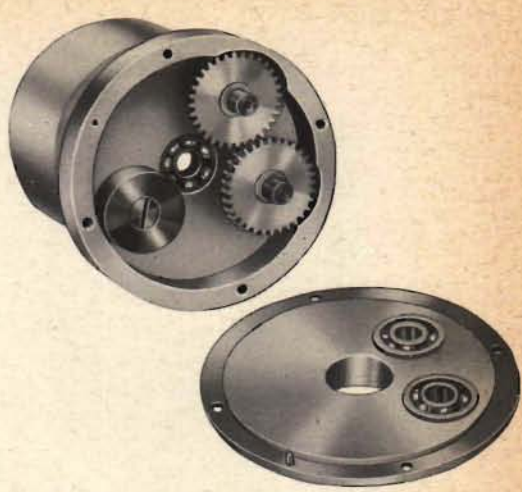
Rough output

Roughness of the follow-up output is usually caused by sticky gearing or sticky contact-arm mountings. Roughness also may be caused by contacts which are dirty, pitted or poorly aligned.



A sticky input shaft line or contact-arm mounting has a more adverse effect on follow-up behavior than a sticky output shaft line. In order to locate stickiness, inspect the shaft lines as recommended on page 102.

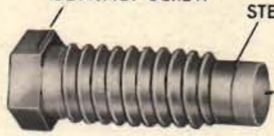
Dirt in the gear meshes or bearings may often be washed out with an approved solvent without disassembly. However, if cleaning operations are conducted within the instrument, every precaution must be taken to avoid washing particles out of one unit into another.



A COMPENSATOR, DISASSEMBLED

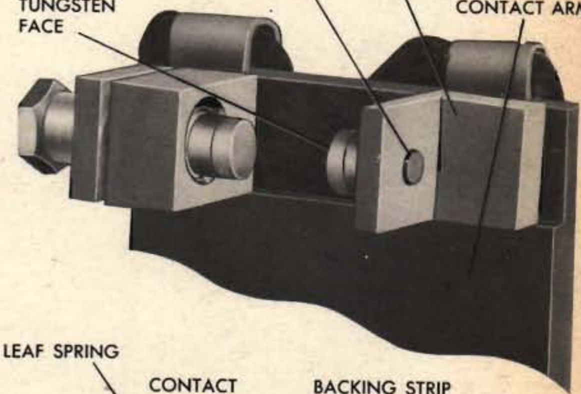
In either the magnetic drag or compensated follow-up control, a sticky magnetic-drag rotor will cause the center contact to move erratically.

In the compensated follow-up, almost imperceptible amounts of foreign matter or dirt in the gear meshes or bearings inside the compensator can cause the center contact-arm assembly, and therefore the follow-up output, to move erratically.

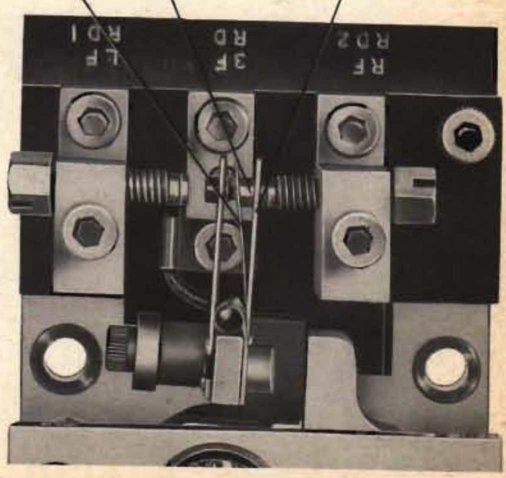


Sluggishness

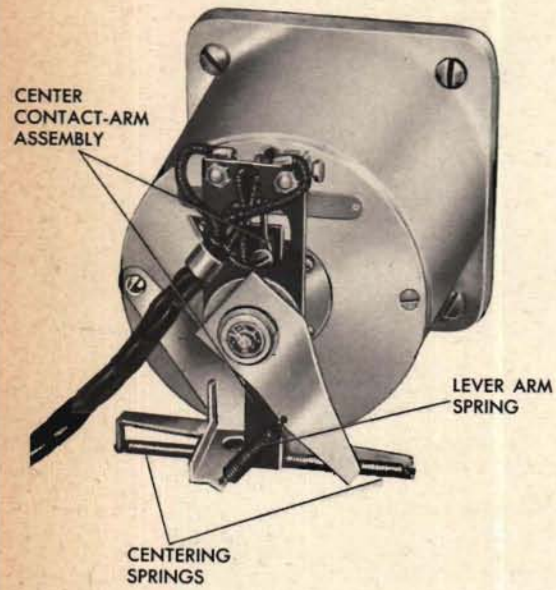
Slowness of a follow-up responding to a signal may indicate high resistance between the contact surfaces, or weak contact pressure.

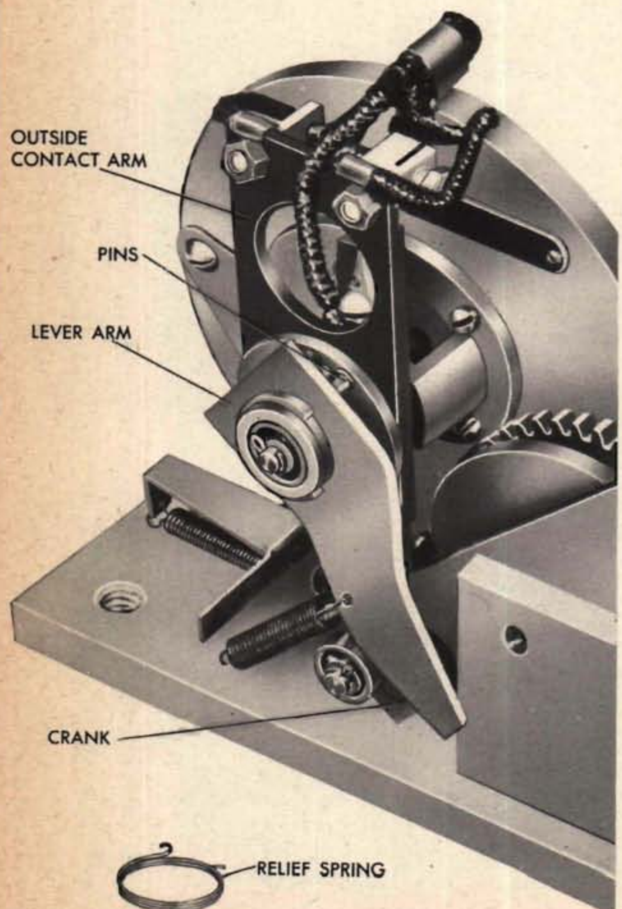


Sluggishness resulting from high resistance between the contact surfaces may be caused by dirty, pitted, oxidized or broken contacts. In order to locate these troubles, examine the contacts closely. See that the contacts are clean and polished. Be sure that the tungsten face has not been broken off the steel shank. Check that the shank is firmly seated in the aluminum contact screw or contact post. Pitting and fouling will take place in a loose joint which may increase the resistance of the circuit enough to cause sluggishness.



In the oscillating unit, poor connection may result if a contact which is riveted to a leaf spring cocks in the backing-strip hole.





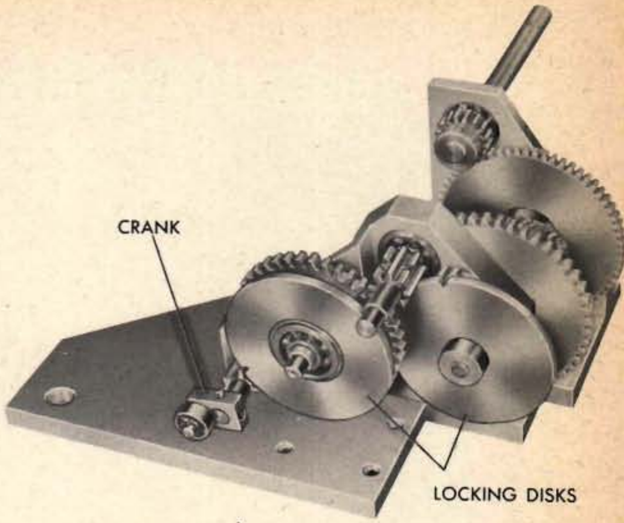
Sluggish operation due to weak contact pressure in the magnetic drag and compensated follow-ups may be caused by damaged centering springs, damage to the relief spring which is wound around the lever-arm sleeve, dirty and sticky plain bearing between the lever arm and outside contact arm, or damage to the lever arm spring.

In order to detect trouble with the centering springs, observe the position of the center contact-arm assembly. It should stand at right angles to the centering springs when the contacts are in the synchronized position (center contact touching neither one of the outside contacts). If it is leaning to one side, probably one of the centering springs is weak.

In order to detect trouble in the outside contact-arm assembly, watch the manner in which it acts as the crank goes through the synchronized position (crank parallel to the lever arm). When the crank is moved up, the lever arm should turn with respect to the outside contact arm. This separates the two pins, winding up the relief spring which limits its contact pressure. When the crank is moved to the down position, the relief spring should return the arms to their original relationship, with the pins touching. If the arms do not return, either the plain bearing is sticky or the spring is weak. Remove the outside contact-arm assembly and separate the arms in order to determine whether the plain bearing or the spring is the cause of the trouble. If the plain bearing is sticky, repair it as directed on page 417. If the spring is damaged, replace it. Sometimes sluggishness due to a weakened relief spring can be alleviated temporarily by shortening one of the loops at the ends of the spring. If this is done, be sure to leave enough spring so that the arms can be turned with respect to each other to separate the pins by at least 3/16 inch.

If the follow-up runs slowly, even though the arms do return and the contacts are in good condition, probably the spring hooked to the lever arm is weak.

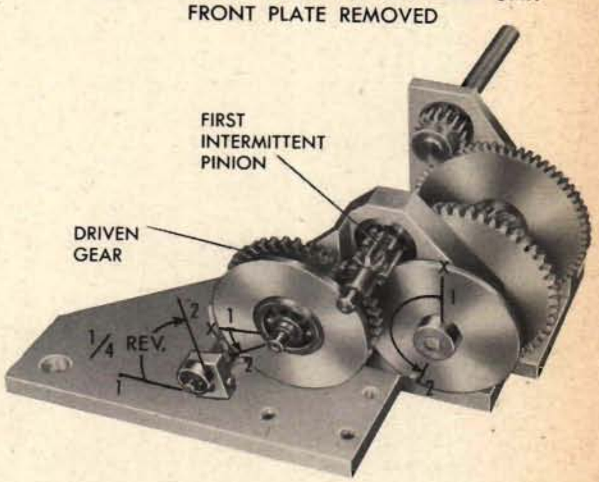
Another cause of sluggishness resulting from weak contact pressure is an incorrect relationship between the two locking disks. Watch the operation of the crank or cam, as the case may be. It should move in steps of 1/4 revolution. Movement in steps of 1/8 revolution indicates that the mesh between the first intermittent pinion and the gear it drives is incorrect by one tooth. This condition can result only from incorrect reassembly. For the correct reassembly procedure, refer to "Reassembling the control unit" of the follow-up in question.



COMPENSATED FOLLOW-UP CONTROL UNIT
FRONT PLATE REMOVED

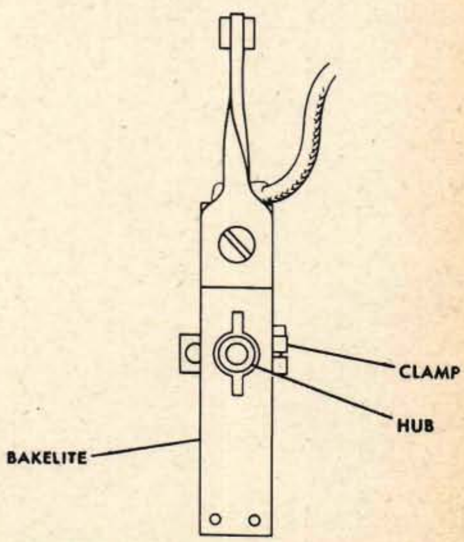
Excessive oscillation

Excessive oscillation of a follow-up usually is caused by a casualty to one of the damping devices.



"Jiggling," or low-amplitude oscillation, may occur if the motor damper or the magnetic drag does not exert the normal amount of torque.

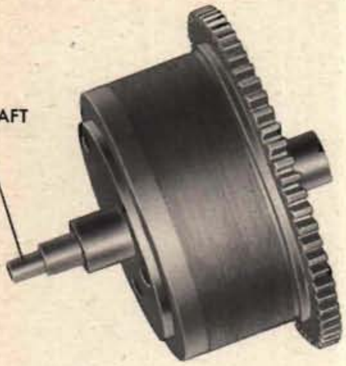
In the magnetic drag and compensated follow-ups, loosened riveting between the bakelite piece of the center contact-arm assembly and the split hub, or a loose clamp on the hub may prevent full application of available torque to the center contact arm.

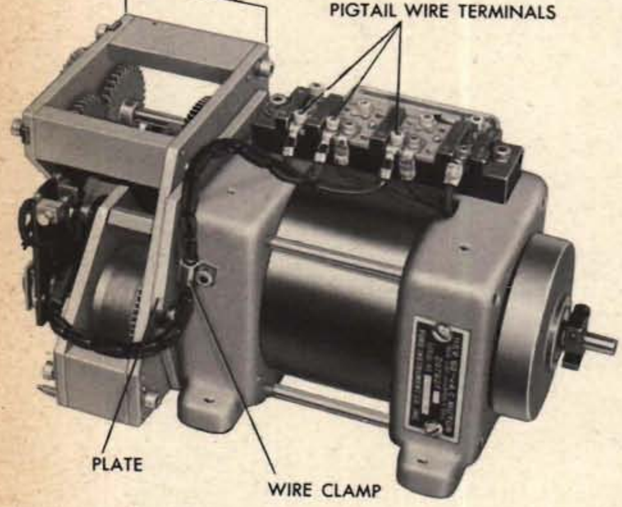


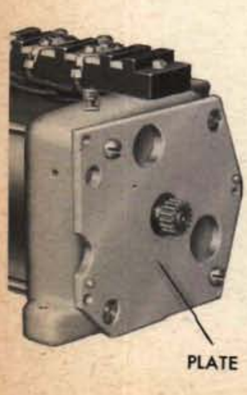
CENTER CONTACT-ARM ASSEMBLY

Similarly, a weakened magnetic damper, an incorrectly adjusted mechanical damper, or a damper loosely clamped to the motor shaft, will decrease the damping action in all follow-ups.

A properly adjusted oscillating follow-up has a perceptible "jiggle." Do not attempt to eliminate this normal condition.







"Hunting," or large-amplitude oscillation, may occur in any follow-up if a damper rotor and case are locked together. In magnetic drag or compensated follow-ups, a sticky magnetic-drag rotor, or reversed left and right-hand leads (L and R) may cause hunting. When the L and R leads are reversed, the follow-up tries to synchronize with the crank arm pointing away from, instead of toward, the spring on the lever arm.

If trouble with a damper is suspected, refer to *Dampers,* page 440. Magnetic drags are similar to magnetic dampers in principle and construction; therefore, *Dampers* may also be used as a guide for trouble-shooting and repairing magnetic drags.

Disassembly

Before disassembling any follow-up, be sure the power supply is disconnected. Tag all spacers so that the parts may be reassembled in the proper relationship to each other.

Disassembly: Magnetic drag follow-up

The entire follow-up can be removed from the instrument as one unit.

Removing the control unit

(Usually the control unit need not be removed in order to disassemble it.)

1 Detach the pigtail wires from the terminal block. Remove the wire clamp.

2 Remove the three screws, and pull the control unit off the plate attached to the motor.

3 Remove the plate attached to the motor. (Note the position of the plate with respect to the motor end cap.)

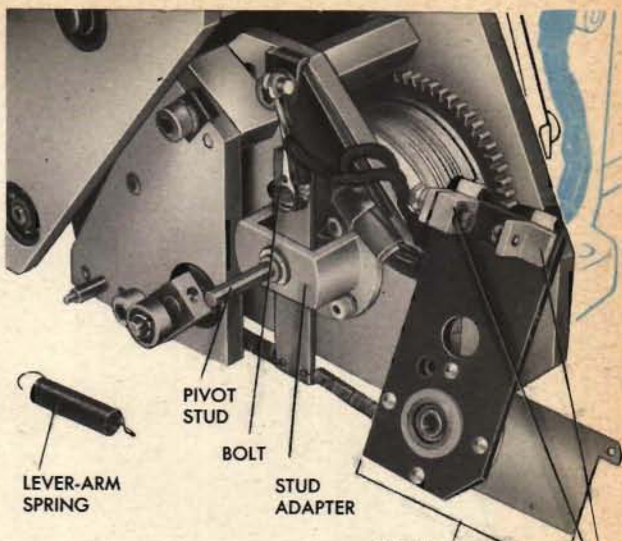
Removing the contacts

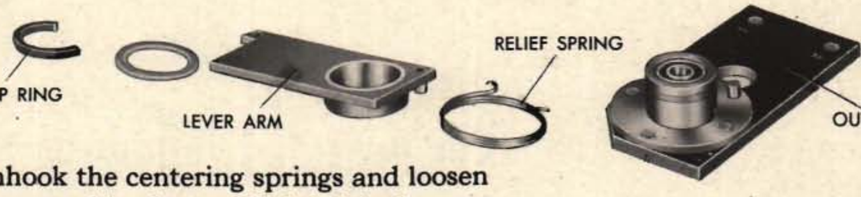
(The contacts can be removed while the control unit is attached to the motor.)

1 Unhook the lever-arm spring, pull the cotter pin out of the pivot stud and pull the outside contact-arm assembly off the stud. (Be careful not to stretch or damage the pigtail wiring.)

2 Remove the contact posts and the pigtail wiring. Tag the terminals.

3 Remove the snap ring and separate the two arms.

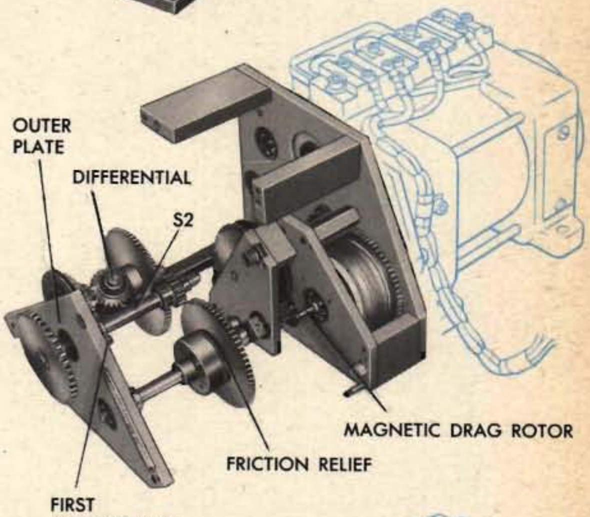




4 Unhook the centering springs and loosen the assembly clamp which holds the center contact arm to the magnetic drag rotor.

5 Take out the screws securing the stud adapter; remove the adapter and the center contact-arm assembly simultaneously.

6 Remove the bolt which holds the pigtail terminal and center contact arm to the bakelite piece and take off the contact arm.

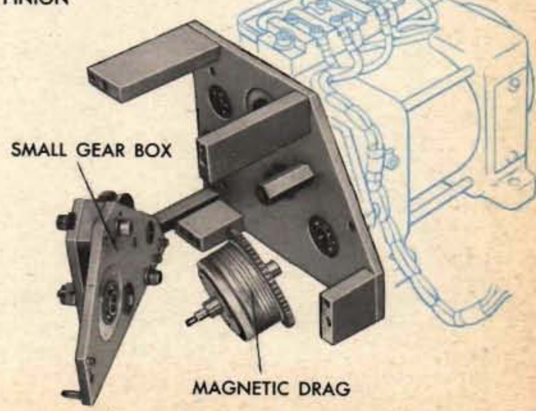


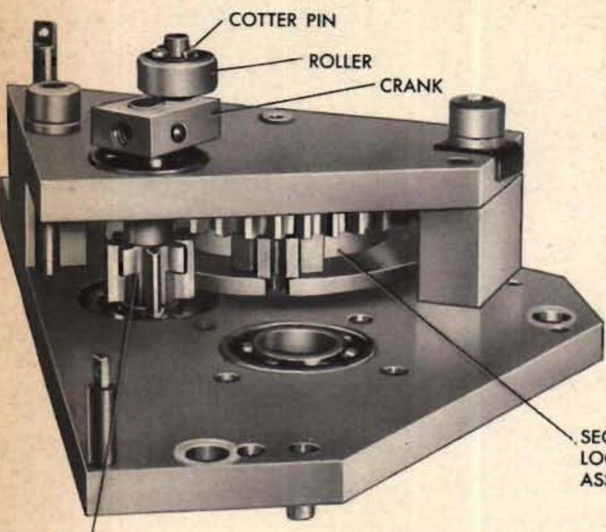
Disassembling the control unit

(The control unit can be disassembled without removing it from the motor.)

1 Take out the screws holding the outer plate; remove the plate together with the differential, friction relief, shaft (S2), and the first intermittent pinion.

2 Remove the small gear box containing the second intermittent pinion. Remove the magnetic drag.





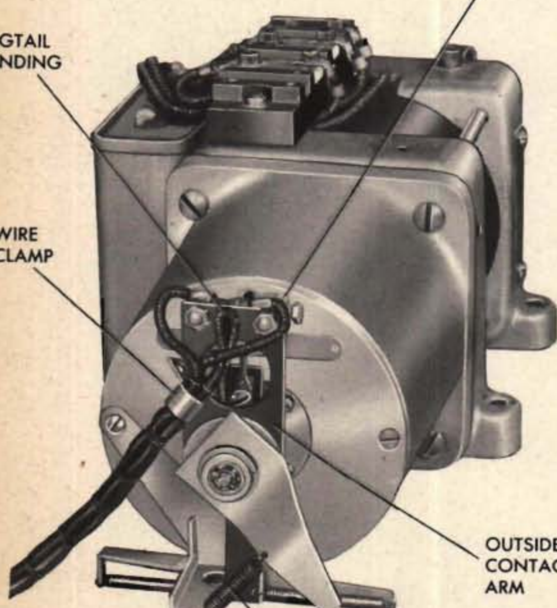
SMALL GEAR BOX

3 Drive out the taper pin to remove the crank. Pull out the cotter pin in order to remove the crank roller.

4 Separate the plates of the small gear box to remove the second locking-disk assembly and the second intermittent pinion.

Disassembly: Compensated follow-up

Usually the motor and the compensator are removed from the instrument as a unit, while the control gearing is removed separately.



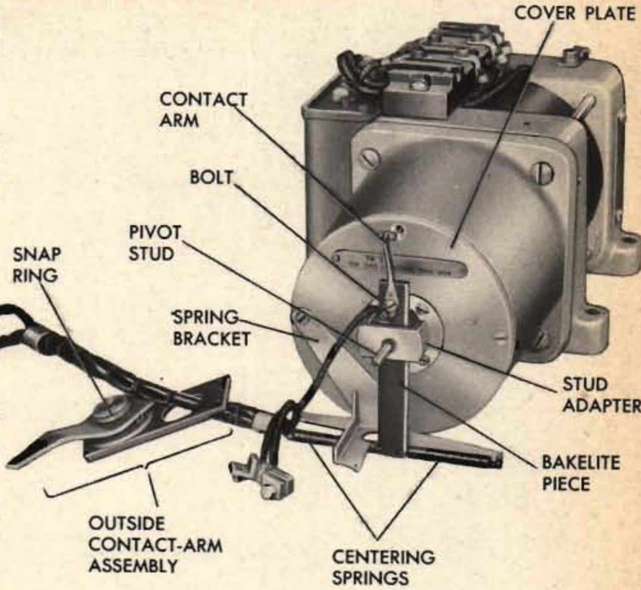
Removing the contacts

1 Disconnect the pigtail wiring from the terminal block and unclamp it from the motor and from the compensator housing; unhook the lever-arm spring.

2 Remove the contact posts and the pigtail wiring from the outside contact arm. Tag the terminals for identification. Cut the thread binding the center-contact pigtail lead to the outside contact arm.

3 Pull the cotter pin out of the pivot stud and remove the outside contact-arm assembly.

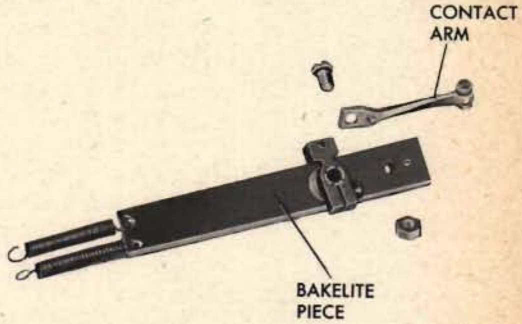
4 Remove the snap ring and separate the lever arm from the outside contact arm.



5 Loosen the center-arm clamp; unhook the centering springs.

6 Take out the stud-adapter screws. Simultaneously, remove the stud adapter and center contact-arm assembly.

7 Remove the bolt which holds the pigtail terminal and center contact arm to the bakelite piece, and take off the contact arm.



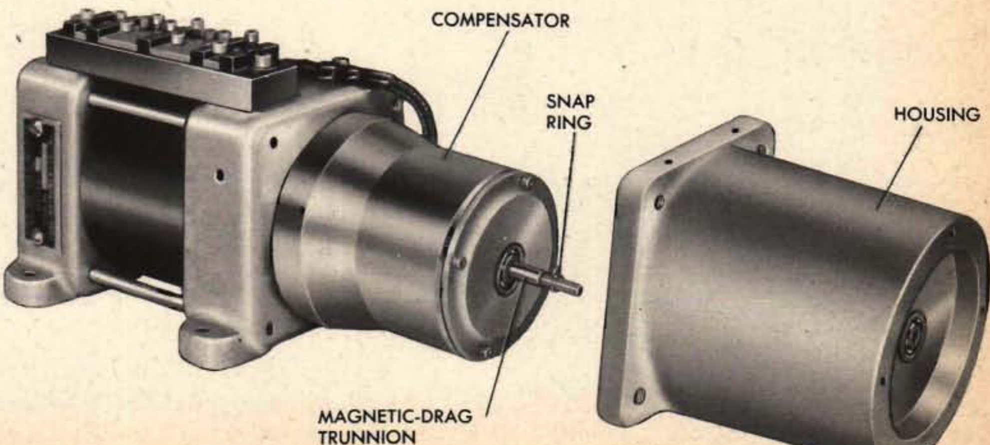
Removing and disassembling the compensator

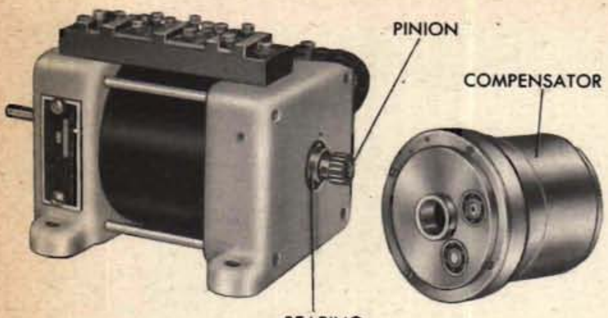
1 Remove the spring bracket.

2 Remove the cover plate from the housing.

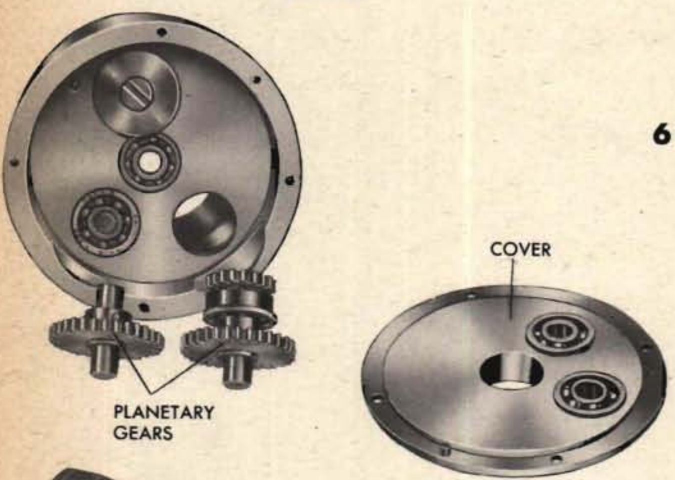
3 In some units a split hub is used to attach a spiral spring to the magnetic-drag trunnion. Carefully spread the split hub to remove it from the shaft.

4 Remove the compensator housing.

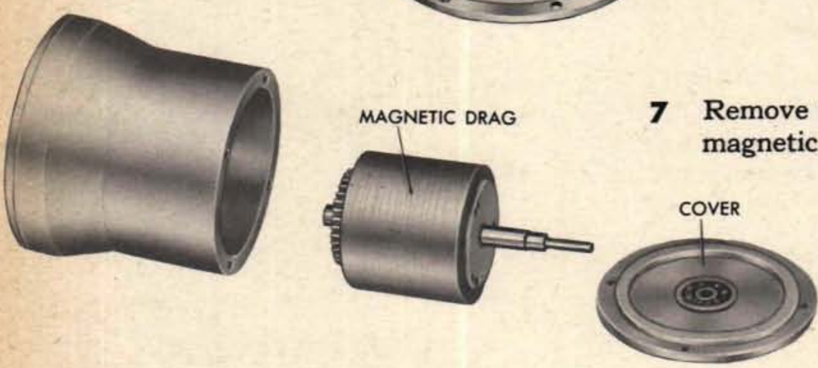




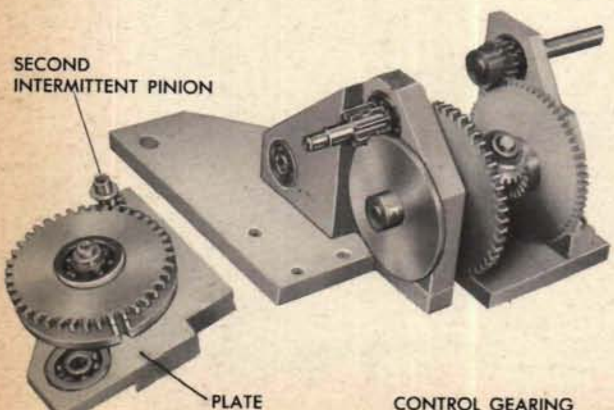
5 Carefully pull the compensator off the bearing on the motor shaft. If the compensator does not come off easily, carefully pry it, using two levers simultaneously to avoid bending the shaft or damaging the pinion.



6 Remove the cover on the motor end of the compensator and lift out the planetary gears.



7 Remove the other cover and lift out the magnetic drag.



CONTROL GEARING

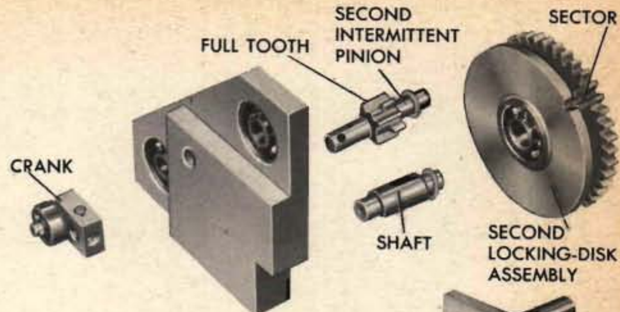
Disassembling the control gearing

Sometimes the follow-up control gearing is mounted on its own plate; sometimes it is mounted on a larger plate which is an integral part of the instrument.

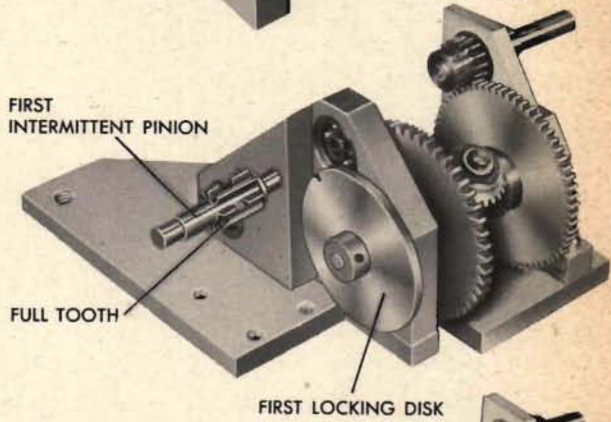
1 Remove the two screws from underneath and lift off the small plate which supports the outer end of the second intermittent pinion.

2 Rotate the second locking-disk assembly until the sector engages a full tooth on the second intermittent pinion. Remove the second locking-disk assembly and its supporting shaft.

3 Drive the taper pin out of the crank; remove the crank and the second intermittent pinion.

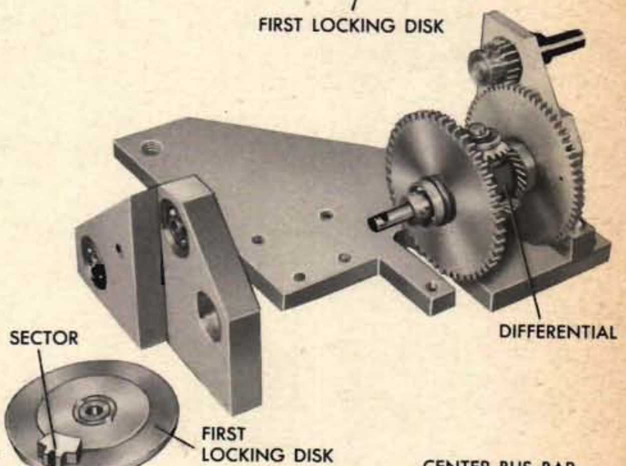


4 Lift out the first intermittent pinion. To do so, it is necessary to rotate the first locking disk, which is on the differential spider, until the sector and a full tooth are in mesh.



5 Drive the taper pin out of the hub of the first locking disk, and remove the disk.

6 Remove the two screws from underneath and lift off the plate which supports one end of the differential. Remove the differential.



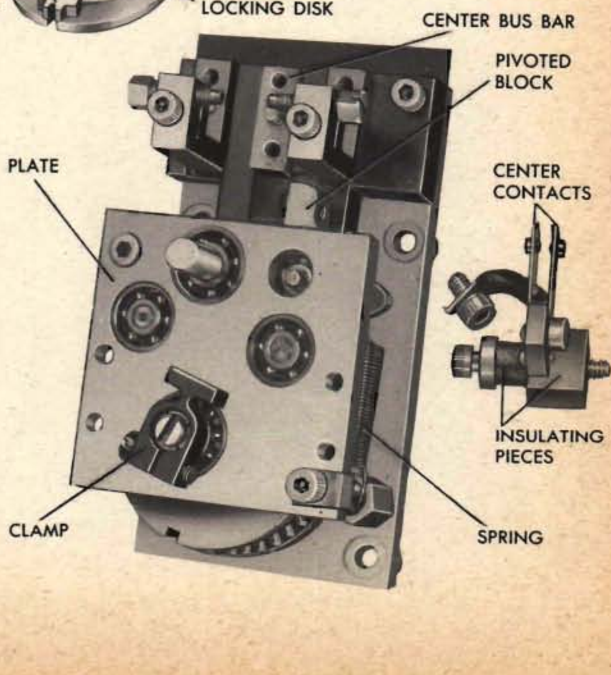
Disassembly: Oscillating follow-up

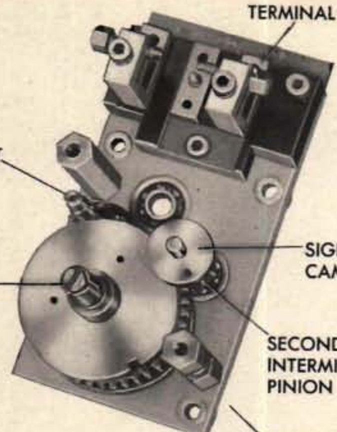
Consult the instrument instruction book for removing the component parts of the follow-up, namely, the control unit, the follow-up differential, and the motor.

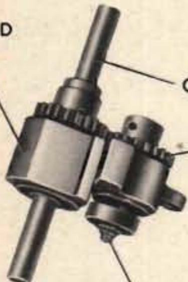
Disassembling the control unit

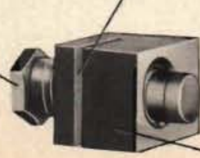
1 Remove the center contacts and the insulating pieces from the pivoted block, and disconnect the pigtail terminal from the center bus bar. Unhook the spring.

2 Remove the clamp. Remove the two screws securing the plate to the posts, and then lift off the plate.









3 Lift out the signal cam.

4 Lift out the pivoted block. Push the oscillator shaft out of the bearings. To remove the eccentric shaft, it is necessary to drive out the taper pin and remove the spur gear.

5 Remove the gear which is clamped on the input shaft.

6 Lift out the input shaft and the first intermittent pinion together.

7 Remove the terminal block from the mounting plate.

Repairing and replacing the parts

Repairing a contact

If a contact is pitted, polish it down to a smooth unmarred finish with a fine oilstone or fine abrasive paper. Keep the contact surface square. Lay the abrasive paper on a flat plate and rub the contact across it. After polishing, clean the contact to remove all abrasive particles. Never use an abrasive coarse enough to leave visible scratch marks, since scratches favor arcing, causing the contacts to become pitted and dirty all over again.

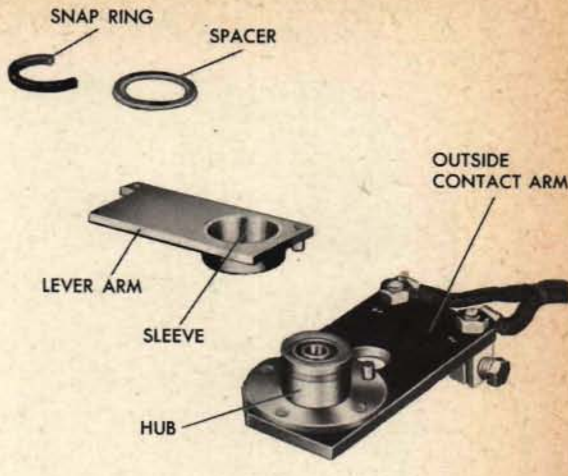
If a contact is loose in a post, rivet the end of the shank which protrudes through the post.

If the contact on the center arm is loose, braze it with an approved silver solder.

To tighten an adjustable-contact screw which is loose in its post, back out the screw until it no longer bridges the split. Using a small pry, open the split *slightly* so the screw fits snugly.

Repairing an outside contact arm

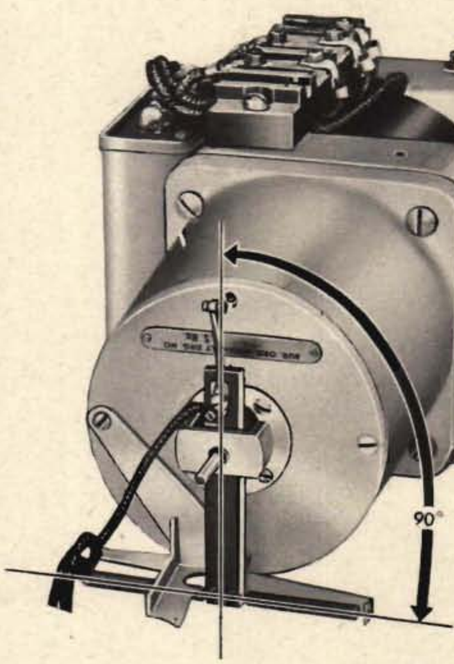
Separate the lever arm from the contact arm. Examine the steel sleeve riveted to the lever arm; remove even the smallest burrs. *Polish* the inside of the sleeve and the end which bears against the hub. *Polish* the aluminum hub riveted to the outside contact arm. Lubricate the hub with *one* drop of an approved lubricant before reassembly. If there is a spacer between the sleeve and the snap ring, be sure that it is smooth and flat. Make sure that there are no sharp edges on the snap ring.



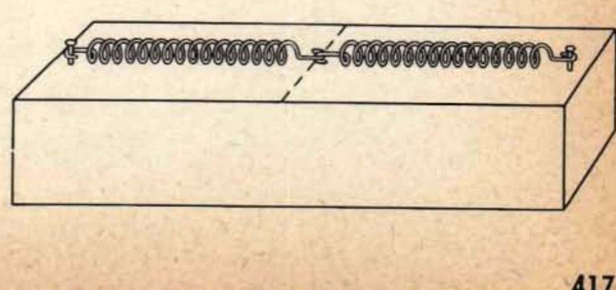
Replacing springs

Replace rusted springs. Put a thin film of oil on a new spring to protect it against corrosion.

When replacing a centering spring, check that it matches its mate in length and strength. A rough check may be made by observing whether the center contact assembly is at right angles to the centering springs.

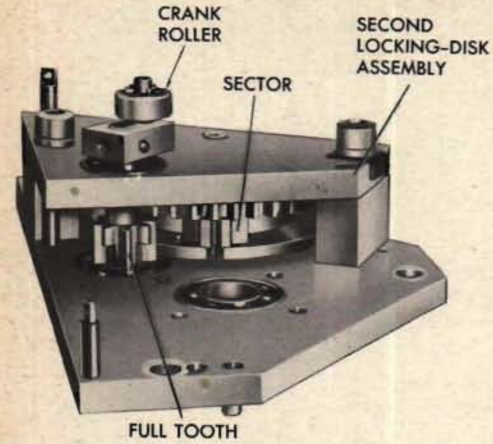


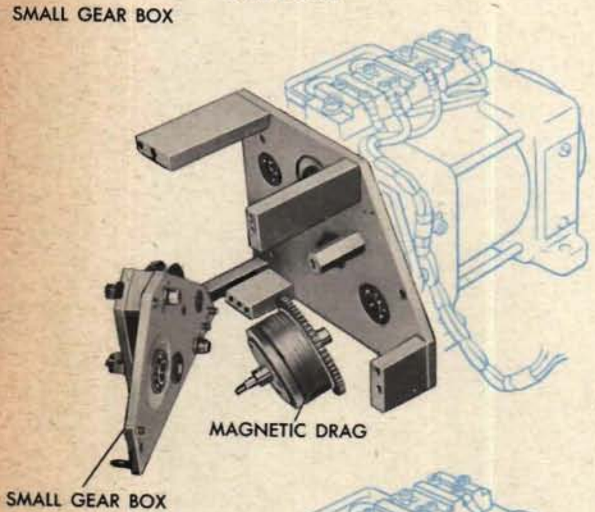
For a more accurate check, remove the springs from the unit. Measure and compare their free length. If their free lengths are equal, check their strength as follows: Measure the distance between the studs on which the springs are hooked. Drive two nails into a piece of wood, spacing them the same distance apart as the studs. Make a mark midway between these two nails. Hook the springs to each other and then to the nails. The point at which the two springs are hooked together should be exactly midway between the nails. If this point is slightly off center, compensate by carefully stretching the shorter of the two springs. If there is a large difference or if the springs are weak or rusted, they should be replaced.

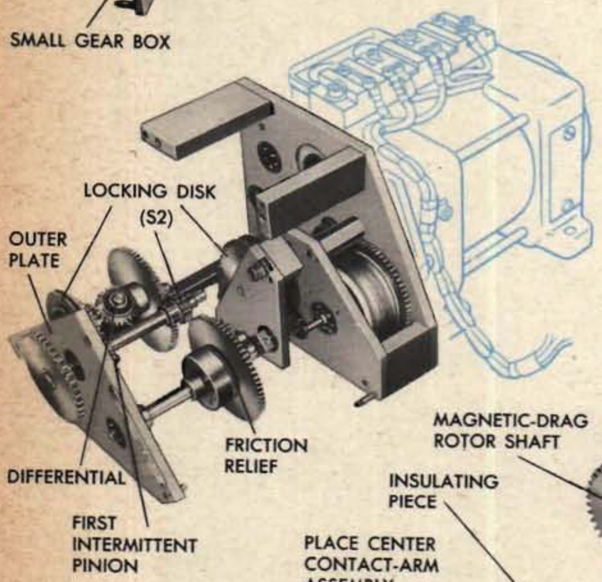


NOTE:
For additional instructions on repair work, refer to the chapters on *Wiring,* page 380; *The Servo Motor,* page 426; *Shaft Lines,* page 92; and *The Bevel Gear Differential,* page 174. The instructions given for the magnetic damper, page 441, apply in general for magnetic drags.

Reassembly: Magnetic drag follow-up







Reassembling the control unit

1 Assemble the second intermittent pinion and the second locking-disk assembly between the plates, meshing a full tooth with the sector.

2 Put the crank roller on the crank and hold it in place with a cotter pin. Pin the crank to the second intermittent pinion.

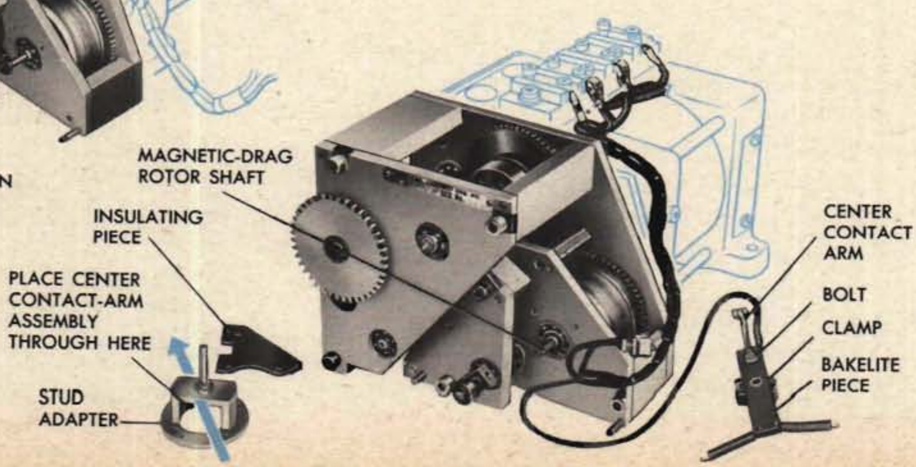
3 Put the magnetic drag in place. Mount the small gear box.

4 Simultaneously replace the differential, the first intermittent pinion, the friction relief (S1), shaft (S2), and the outer plate. In order to obtain the correct relationship between the two locking disks, it is essential to assemble the first intermittent pinion so that the sectors on both locking disks will simultaneously be in mesh with full teeth of both intermittent pinions.

Replacing the contacts

1 Bolt the center contact pigtail terminal and the center contact arm to the bakelite piece.

2 Place the center contact-arm assembly through the stud adapter as indicated; then push it on the magnetic drag rotor shaft, and tighten the clamp. Secure the stud adapter and the insulating piece to the plate. Hook the centering springs to the posts.

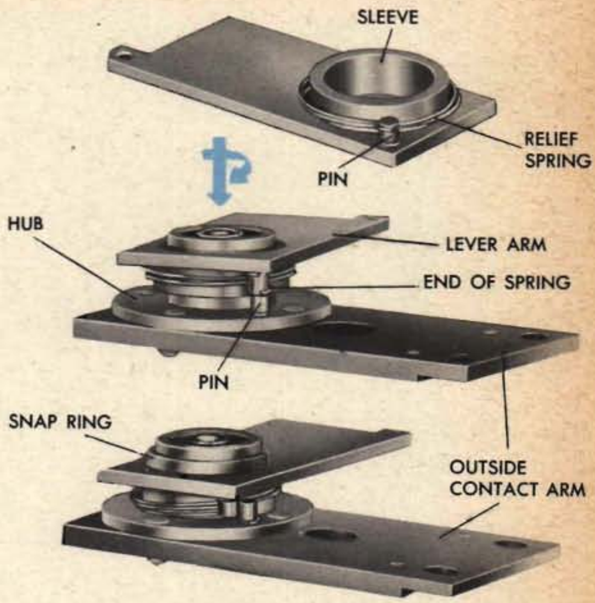


3 Place the relief spring over the lever-arm sleeve, temporarily hooking both ends on the pin.

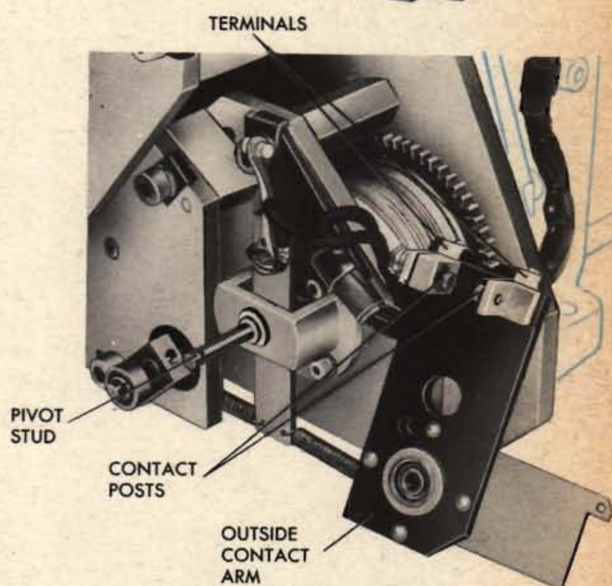
4 Apply one drop of approved lubricant to the sleeve, and slide the hub of the outside contact arm into the sleeve.

5 Holding the arms so that the pins meet end to end, slide one end of the relief spring onto the outside contact-arm pin as shown. Turn the lever arm clockwise and push it down into place.

6 Put on the spacer and snap ring.

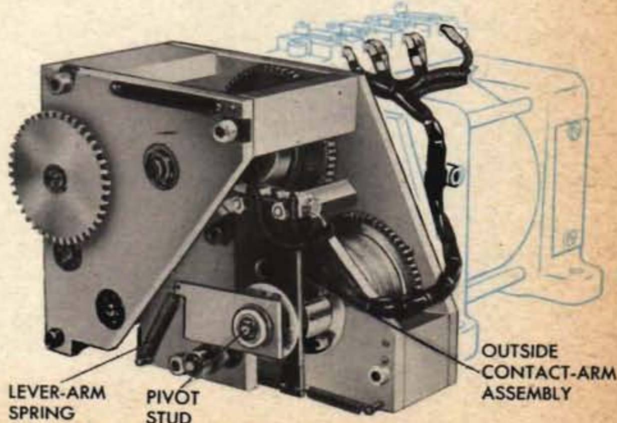


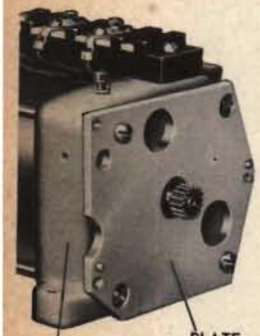
7 Mount the terminals and contact posts in their places on the outside contact arm.



8 Mount the outside contact-arm assembly on the pivot stud and secure it with a spacer and cotter pin.

9 Hook the spring on the lever arm and to the post.





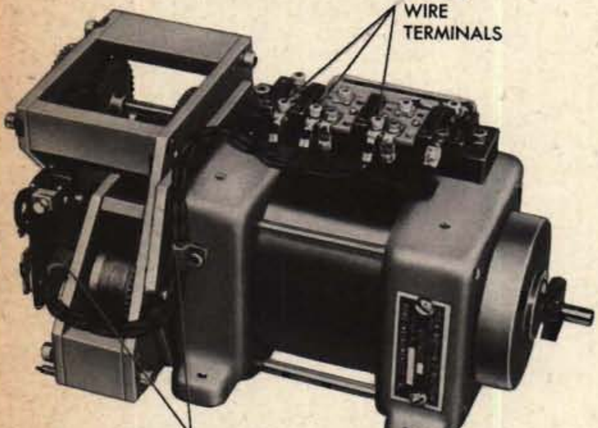
CONTROL UNIT

Replacing the control unit

1 Mount the plate on the motor end cap.

2 Mount the control unit on the plate.

3 Attach the pigtail wires to the terminal block according to the designations stamped on the terminal lugs. Clamp the pigtail wire cable.

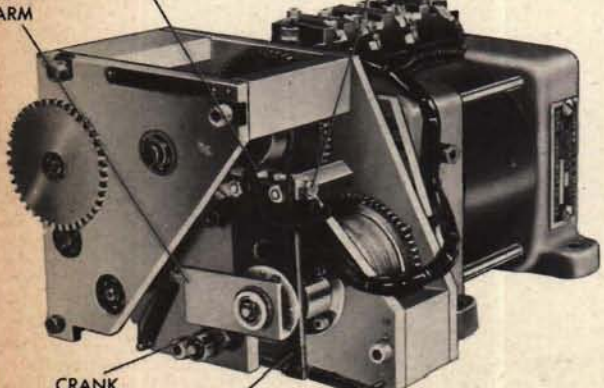


Adjusting the contacts

1 By using matched centering springs (see page 417), make the bakelite piece of the center contact-arm assembly stand at right angles to the centering springs. The center contact arm should be aligned with the bakelite piece.

2 Set and wedge the crank parallel to the lever arm, with the roller toward the spring. The center and fixed outside contact surfaces should be parallel and about 0.005 inch apart. If they are not, loosen the fixed outside contact post and shift it within the clearance hole.

3 Turn the contact screw until this contact also is about 0.005 inch from the center contact, making a total gap of about 0.010 inch. If this outside contact is askew, align it by shifting the contact post.



Bench checking the unit

1 Check the unit against the assembly drawing.

2 The center contact arm should be at right angles to the centering springs when the outside contacts are not touching the center contact.

3 The contact surfaces should meet flush and in line.

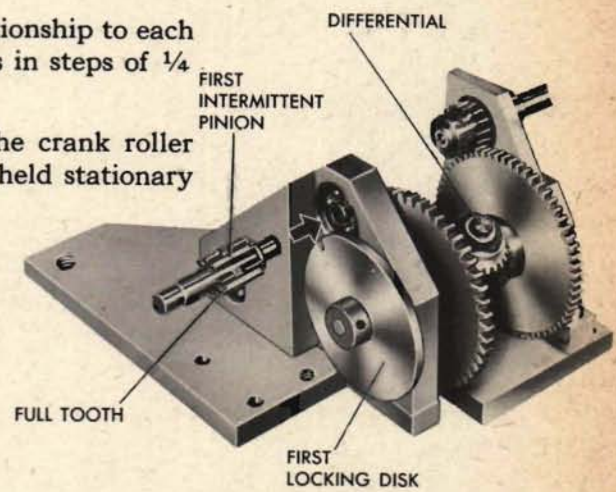
4 The contact surfaces should be clean.

5 When the crank is parallel to the lever arm and the roller is toward the spring, the center contact should be centralized.

6 The gears and bearings should be clean, lubricated, and free to turn. End shake of shafts and lost motion in gear meshes should be at a minimum.

7 The locking disks should be in correct relationship to each other. This is indicated if the crank moves in steps of ¼ revolution.

8 The follow-up should synchronize with the crank roller toward the spring when the input gear is held stationary and the power is ON.



Reassembly: Compensated follow-up

Reassembling the control gearing

1 Mount the differential between the two plates.

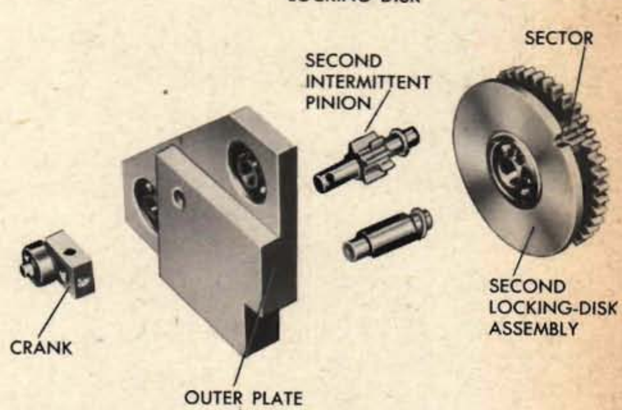
2 Pin the first locking disk to the spider shaft, hub side out.

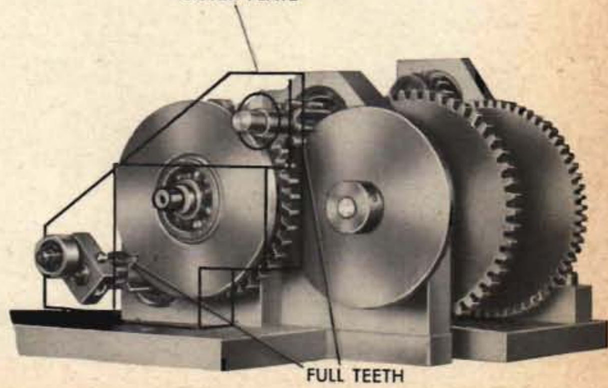
3 Mount the first intermittent pinion, meshing a full tooth with the sector.

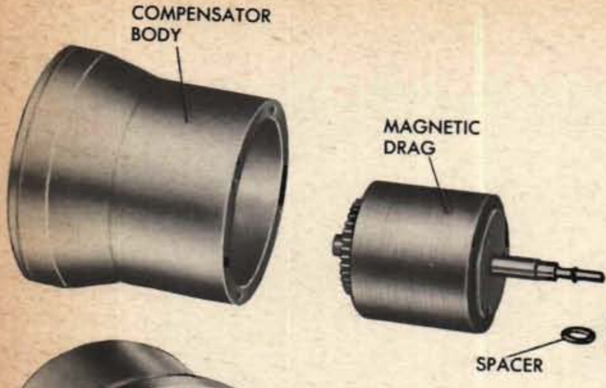
4 Put the second intermittent pinion in the outer plate and pin the crank to the shaft.

5 Mount the second locking-disk assembly on its shaft in the outer plate with the disk toward the plate.

6 Mount the outer plate. In order to obtain the correct relationship between the two locking disks, it is essential for the sectors on both locking disks to mesh simultaneously with full teeth on the intermittent pinions.





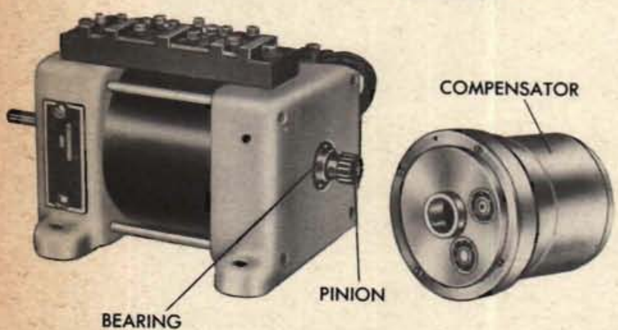


Reassembling the compensator

1 Place the magnetic drag and its spacers within the compensator body and secure the end cover. Check the end shake of the magnetic-drag body.

2 Put the gears and spacers in place in the compensator body. Be sure the marked teeth mesh. Secure the other cover. Check the end shake of the shafts.

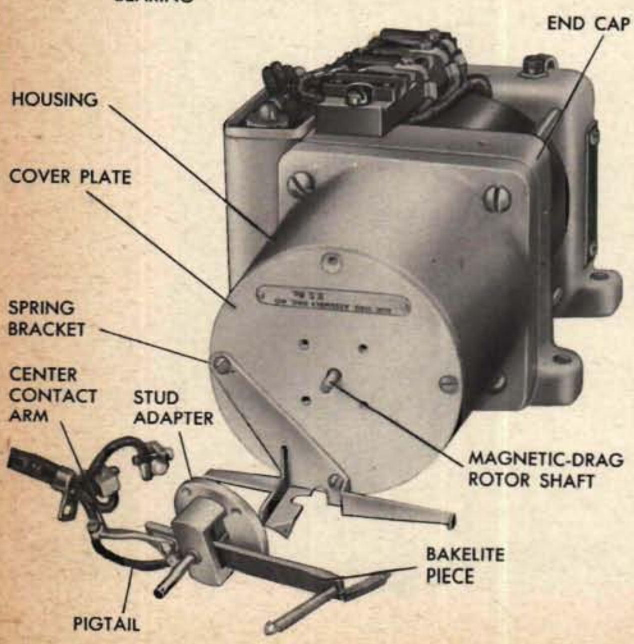
3 Carefully push the compensator onto the bearing on the motor shaft and into mesh with the pinion.



4 Slip the housing over the compensator and secure it to the motor end cap.

5 If the unit had a spiral spring in the housing, push it back in place on the magnetic-drag trunnion.

6 Secure the cover plate and the spring bracket to the housing.



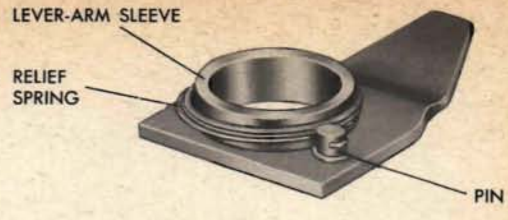
Replacing the contacts

1 Bolt the center contact pigtail terminal and the center contact arm to the bakelite piece.

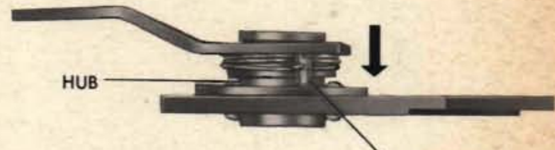
2 Place the center contact assembly through the adapter; then push it on the magnetic-drag rotor shaft and tighten the clamp.

3 Secure the adapter with screws, and hook the centering springs to the spring bracket.

4 Place the relief spring over the lever-arm sleeve, temporarily hooking both ends on the pin.



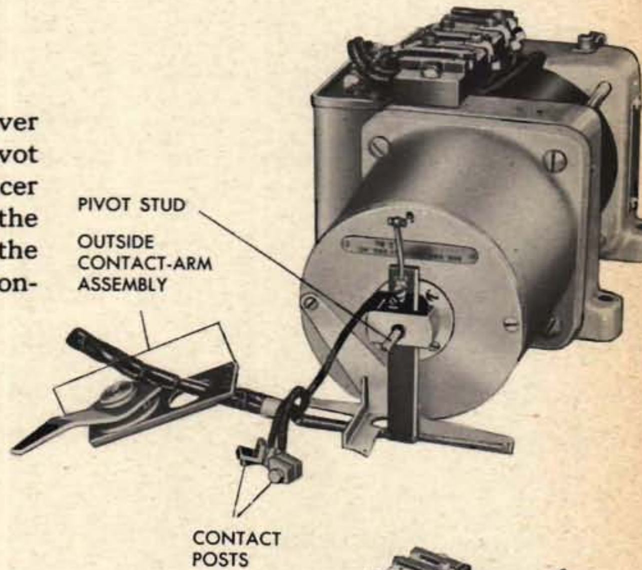
5 Put one drop of approved lubricant in the sleeve and slide the lever arm onto the outside contact-arm hub.



6 Holding the arms so that the pins meet end to end, slide one end of the relief spring onto the outside contact-arm pin. Turn the lever arm counterclockwise and push it down into place.

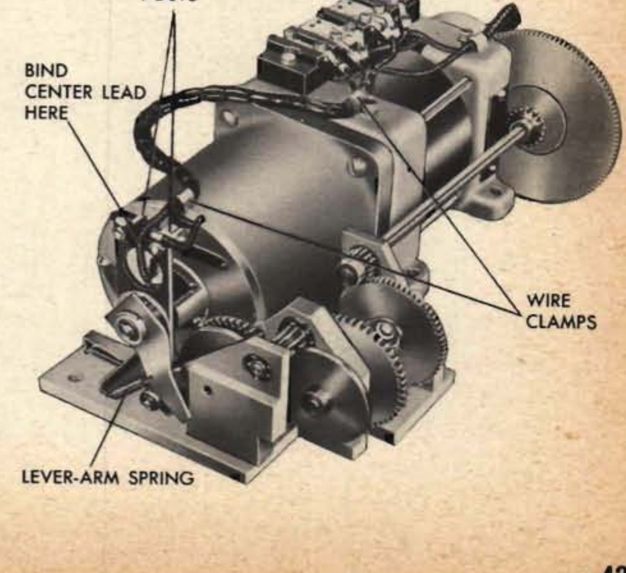
7 Put on the spacer and the snap ring.

8 Slide the outside contact assembly over the pigtail wiring; mount it on the pivot stud and secure it in place with a spacer and cotter pin. Hook the spring to the lever arm and to the bracket. Bind the center contact pigtail to the outside contact arm.



9 Mount the contact posts and the pigtail wire terminals on the outside contact arm according to the tags attached at disassembly.

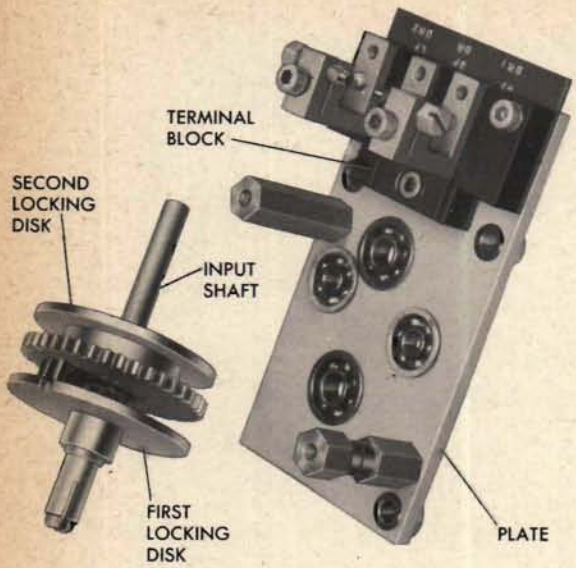
10 Clamp the pigtail wiring in place.



ADJUST the contacts of the compensated follow-up in the same manner as those on the magnetic-drag follow-up, page 420.

BENCH CHECK the compensated follow-up in the same manner as the magnetic-drag follow-up, page 420.

Reassembly: Oscillating follow-up control



1 Mount the terminal block on the plate.

2 Place the locking-disk assemblies on the input shaft in the order shown.

3 Mount the input shaft in the plate. Clamp the input gear on the shaft.

4 Put the eccentric shaft in the pivoted block, and pin the gear in place. Push the oscillator shaft into the pivoted block.

5 Mount the pivoted block in the plate.

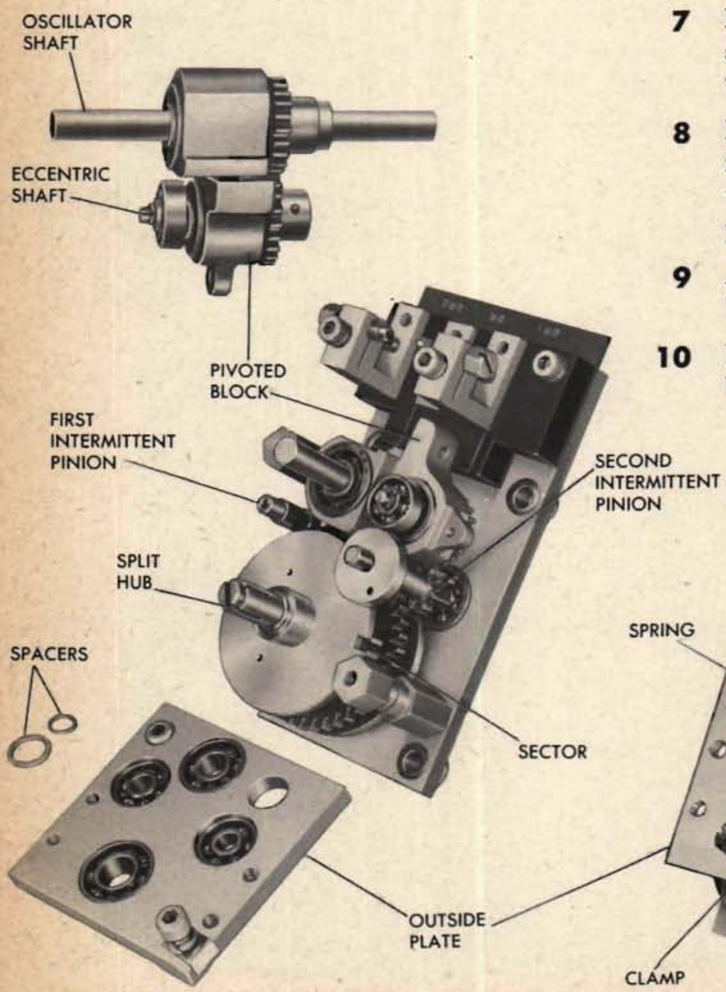
6 Insert the first and second intermittent pinions so that full teeth mesh with both sectors simultaneously.

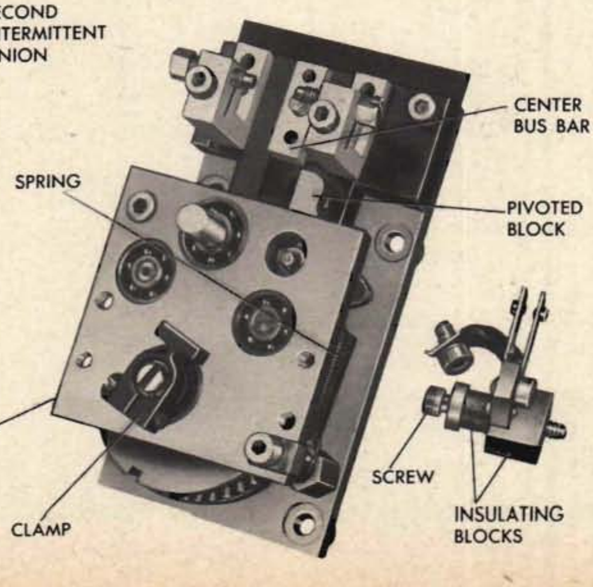
7 Place the spacers on their respective shafts and mount the outside plate. Put the clamp on the split hub.

8 Hold the center contact and the insulating blocks together. Pass the screw through them and secure them to the pivoted block.

9 Attach the pigtail terminal to the center bus bar.

10 Hook the spring to the post and to the block.





Adjusting the contacts

Only an approximate adjustment can be obtained on the bench. Consult the instrument OP for making the final adjustments in the instrument.

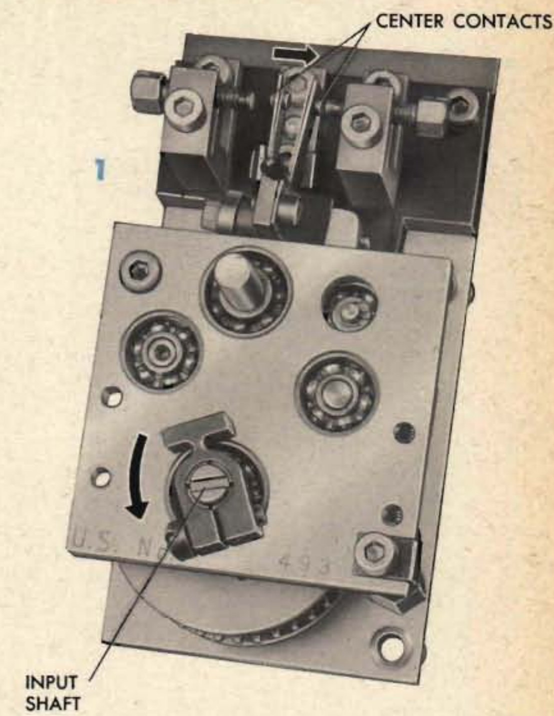
1 Displace the center contacts to one side by turning the input shaft.

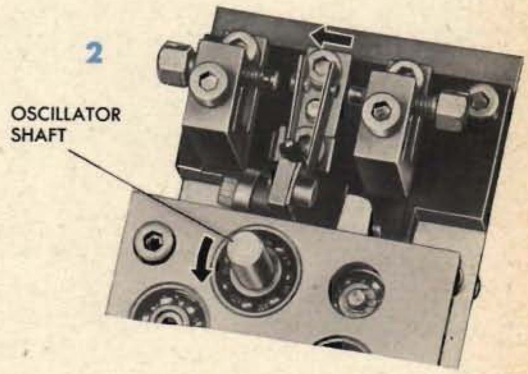
2 Turn the oscillator shaft until the center contacts are displaced the maximum amount toward the center.

3 Turn the contact screw until it just touches the center contact. Then turn the contact screw in by one half-revolution.

4 With the center contacts thrown to the opposite side, repeat steps 2 and 3 for the other contact screw.

This process positions the outside contacts equidistant from the working center of the oscillating center contact. To preserve this relationship when making the final adjustments, always move both contact screws equally.





Bench checking the unit

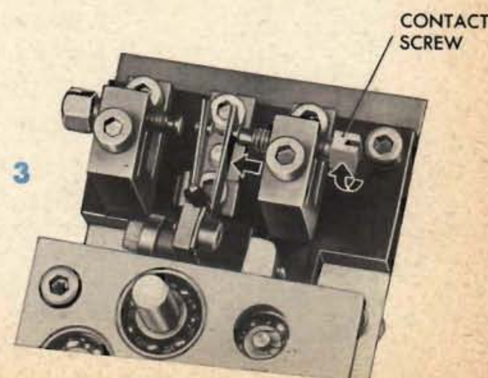
Unless a special test fixture is available, the follow-up cannot be run on the bench.

1 Check the unit against the assembly drawing.

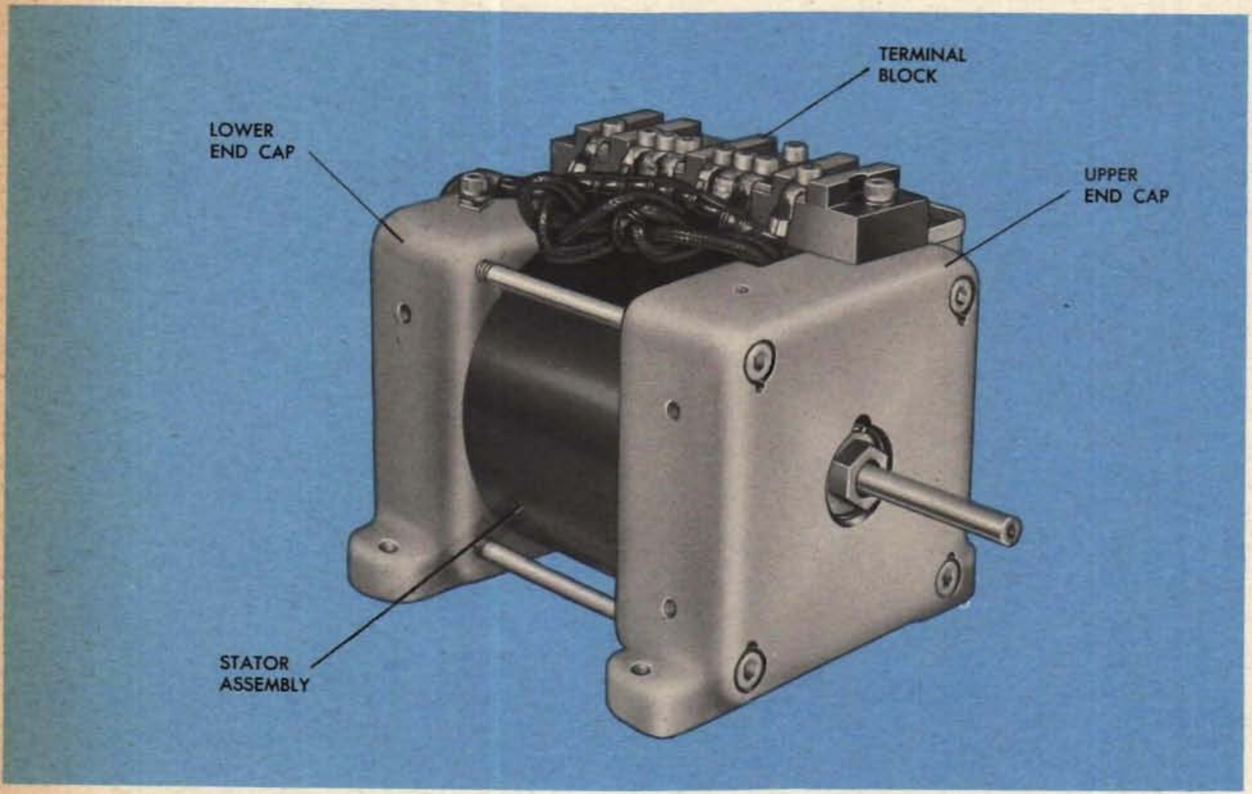
2 The gears and bearings should be clean, lubricated, and free to turn. End shake of shafts and lost motion in gear meshes should be at a minimum.

3 The contact surfaces should be clean, meet flush, and be in line.

4 The locking disks should be in correct relationship to each other. This is indicated if the cam moves in steps of ¼ revolution.



THE SERVO MOTOR



The servo motor is used most frequently in various types of follow-ups where it functions as a torque amplifier. It is also used as a time motor to turn the time shaft line. The servo motor is an induction-type motor in which the rotor is not connected directly to a power supply but is turned by the action of a magnetic field set up by current flowing in two stator coils.

The servo motor can be checked but not repaired while it is in the instrument. Because its removal may disturb the shafting to other units, use the instrument OP to check both the input wiring and the output shafting to make sure that the trouble is actually in the motor.

This chapter is concerned only with the motor. It assumes that all associated equipment such as wiring, capacitors, gearing, or follow-ups, have been checked and the motor is known to be defective. Always REPLACE a defective motor with a new motor when a replacement is available.

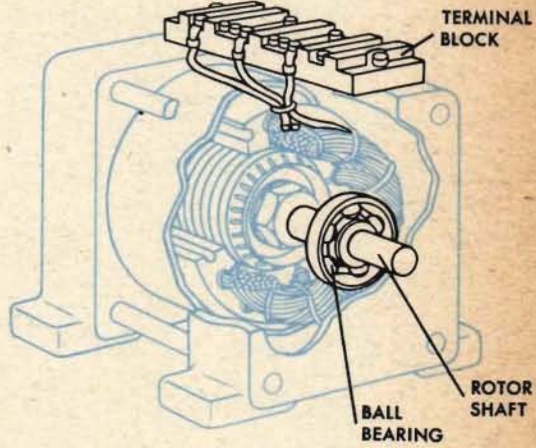
If no replacement is at hand, the following symptoms should be checked, with the motor either in the instrument or on the bench, to determine whether it can be repaired.

Typical symptoms

Noisy operation

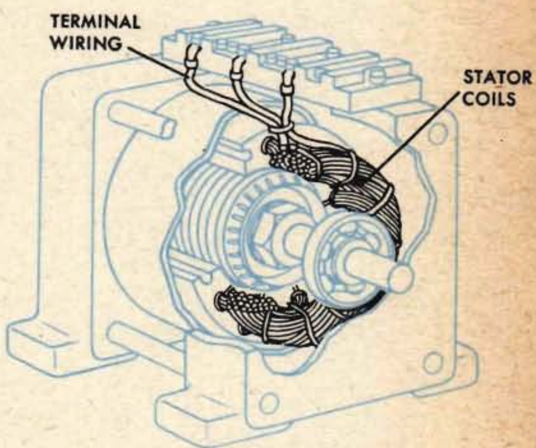
This is detected by running the motor. It can be checked with the motor in place if the motor can be disconnected from the associated gearing. If this check cannot be made in place, the motor must be removed. In either case, the motor must be disassembled and inspected for a bent rotor shaft or damaged or dirty bearings.

If the motor has a reduction gear box, the trouble may be in the reduction gears or bearings. Repair of a gear box usually requires its removal from the motor.



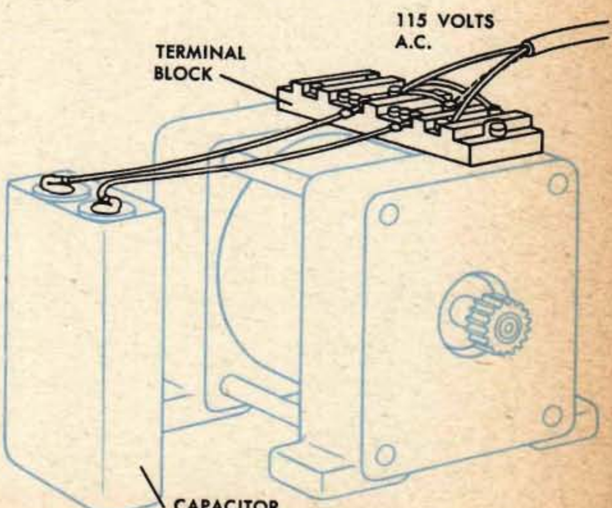
Erratic operation

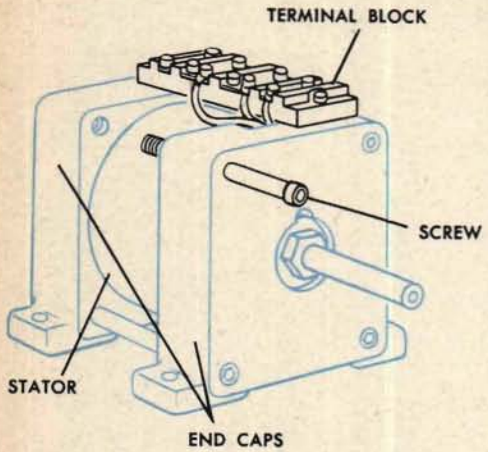
Check the wiring for intermittent short circuits or open circuits. Try to spin the motor shaft by hand. If the motor jams or sticks on this test, the trouble is probably due to damaged or dirty rotor bearings or a bent rotor shaft. Dirty bearings may cause the motor to start slowly. The motor should be disassembled to clean dirty bearings or to straighten a bent shaft. Damaged bearings or a badly bent shaft require replacement.

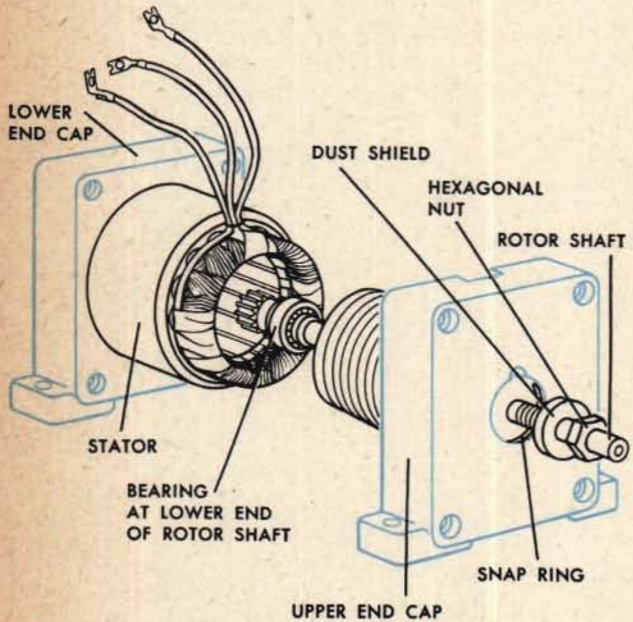


Motor does not drive

Using a test capacitor of the proper value, connect the motor to a 115-volt A.C. supply. If the motor does not run, a stator coil may be burned out, or open, or a lead from the motor terminal block may be open. Inspect the leads for damage. If they are in satisfactory condition, test the stator coils with an ohmmeter and compare the resistance readings with the values given on the assembly drawing. If a stator coil is burned out or open, the motor should be replaced.







Disassembling the unit

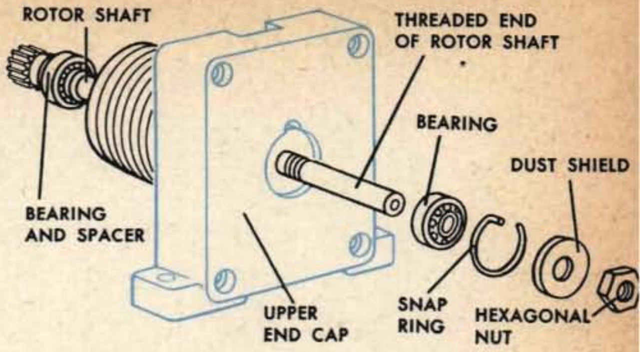
1. Remove the screws holding the motor leads to the terminal block.
2. Remove the terminal block.
3. Remove the four long screws which hold the end caps and stator together.
4. If a gear on the rotor shaft will not permit the shaft to slide through the hole in the lower end cap, remove the gear.
5. Remove the upper end cap from the stator shell. If necessary, start the cap by tapping it lightly with a plastic hammer. The rotor shaft is held in the upper end cap and will come out with it.
6. Remove the hexagonal nut on the rotor shaft near the bearing in the upper end cap.
7. Remove the dust shield.
8. Pull the rotor out of the bearing.
9. If the bearing is to be removed, remove the snap ring from the end cap.
10. Remove the stator from the lower end cap.
11. If either the bearing or the rotor is to be replaced, remove the bearing from the lower end of the rotor shaft.

Repair and replacement of parts

To straighten a bent rotor shaft, follow the procedure on page 69. Replace a burned out or open stator assembly. Replace worn or damaged bearings.

Reassembling the unit

1. Be sure all parts are clean. Wipe the surfaces free of dust and grit.
2. Place the bearing and its spacer on the lower end of the rotor shaft.



3 Place the other bearing in the upper end cap. Replace the snap ring.

4 Insert the threaded end of the rotor shaft through the upper end cap.

5 Place the dust shield over the bearing.

6 Replace the hexagonal nut on the threaded portion of the rotor shaft.

7 Fit the stator shell into the upper end cap. Be sure the stator leads are in the upper-end-cap slot.

8 Center the lower end cap on the shaft and move it into position over the bearing until it seats on the ridge of the stator shell.

9 Place the assembly on a flat surface to check that the mounting surfaces of the end caps are in the same plane.

10 Insert the four long screws and tighten them by hand.

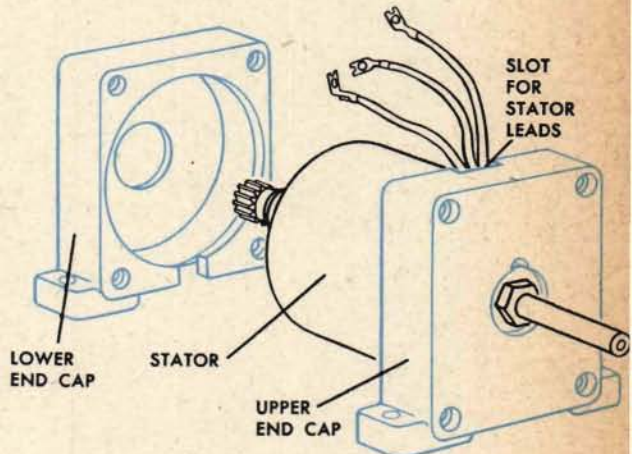
11 Spin the rotor shaft by hand. If the shaft does not spin freely, check that the end caps fit squarely on the stator. The shaft must spin freely before further assembly is attempted.

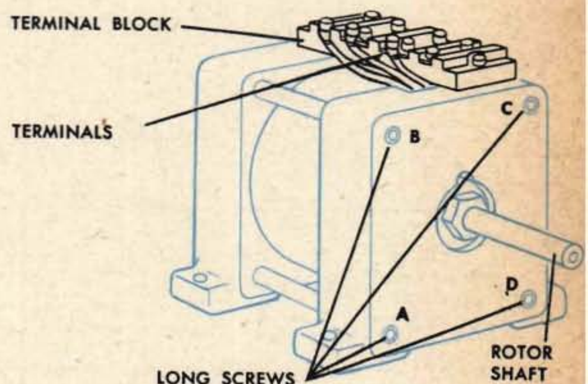
12 Tighten the long screws, not in rotation, but in the sequence A, C, B, D.

13 Screw the terminal block to the end caps.

14 Connect the terminals labeled L, C, and R, to the proper bus bars on the terminal block.

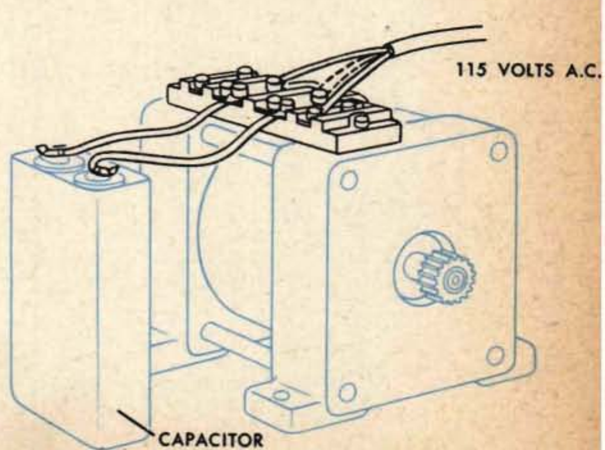
15 Put a drop of approved lubricant in each bearing.



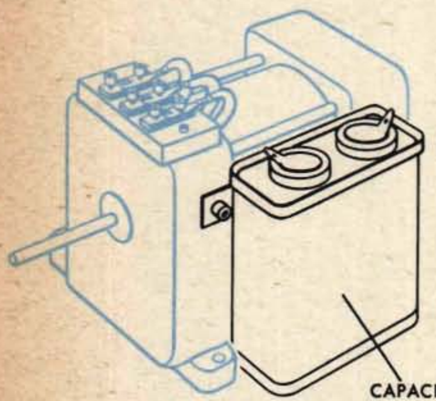


Bench checking the unit

To check that the motor runs freely in both directions, place a test capacitor across the L and R terminals, and energize the motor by supplying 115-volt A.C. power first to the L and C terminals, and then to the R and C terminals.



THE CAPACITOR



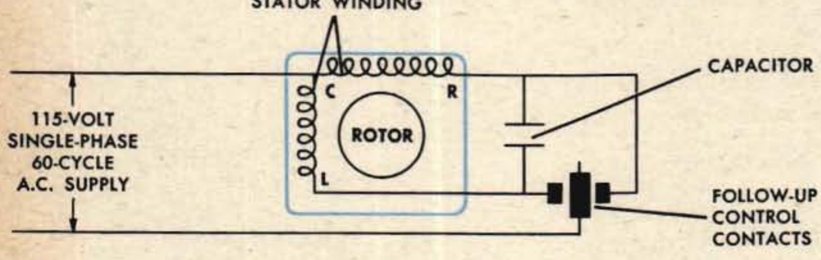
The capacitor, or condenser, supplies the necessary current phase lag to the second field coil to assure adequate starting and running torque.

The active parts of the capacitor are the metal plates, which conduct the current, and the insulating or "plate-spacing" medium. All are contained in a corrosion-resistant case with suitable mounting straps.

A most important fact to remember is that each servo installation calls for a specific size of condenser. Capacities vary with particular motors, from 1 to 16 microfarads.

If tests indicate that a servo is not operating properly, disconnect the condenser in use and substitute one which is known to be of the proper capacity and in good condition. If this clears the trouble, install a replacement condenser and discard the defective one.

CAUTION:
Before working on a condenser, turn the power supply OFF and discharge the condenser by short-circuiting the condenser terminals.



Typical symptoms

Because of the way in which a condenser is constructed, there is little or no possibility of effecting repairs to the unit itself. The obvious repair is "replacement."

However, in testing servos, the following symptoms may indicate faulty capacitors:

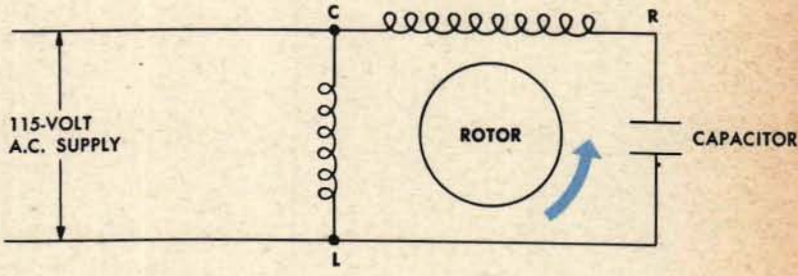
1 Servo does not drive.

2 Servo drives very sluggishly.

3 Servo overheats.

Locating the cause

1 If the servo does not drive with sufficient torque, the capacity of the condenser may be too low. This may be the result of a leak in the case, allowing the insulating medium to run out. Or, the leads to the metal plates may be "open." In this case capacity would be zero.



2 If the servo drives sluggishly, the condenser may be "partially short-circuited," allowing current to pass directly from one plate to the other. This condition may be located with a resistance measuring device (resistance bridge, ohmmeter, etc.).

3 Servo overheating may be due to a short-circuited condenser. In this case the insulating medium has broken down allowing the two plates of the condenser to make direct contact. Reference to the circuit diagram shows that such a condition passes all current through a single coil.

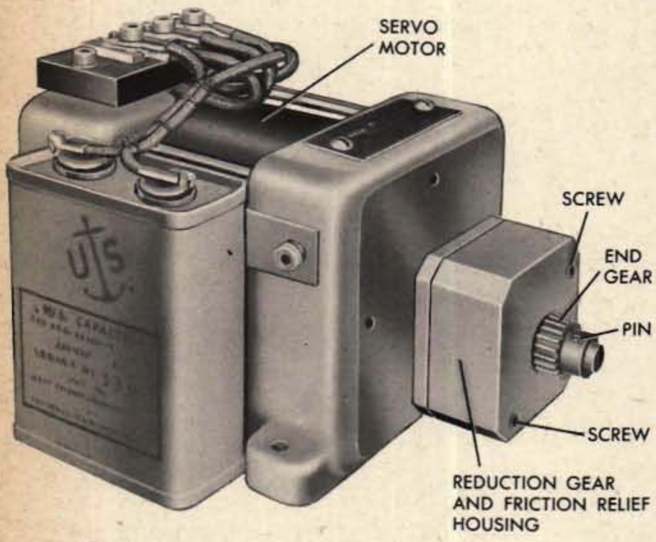
General practice

As previously indicated, there is very little that may be done in the way of actually "repairing" a condenser.

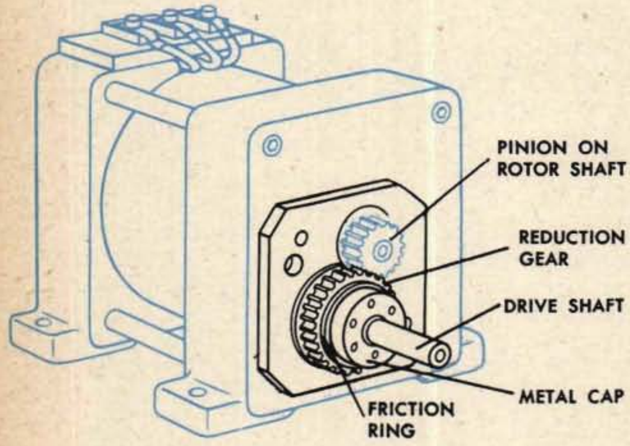
Replacement is the obvious solution.

Be certain that the replacement unit has the proper capacity. If the data on the name plate is not clear, measure the capacity. If, in an emergency, a condenser is used for which the characteristics are not available, make sure of two things: that minimum working voltage is 115 volts A.C., and that it has the proper capacity.

FRICTION RELIEF AND REDUCTION GEAR



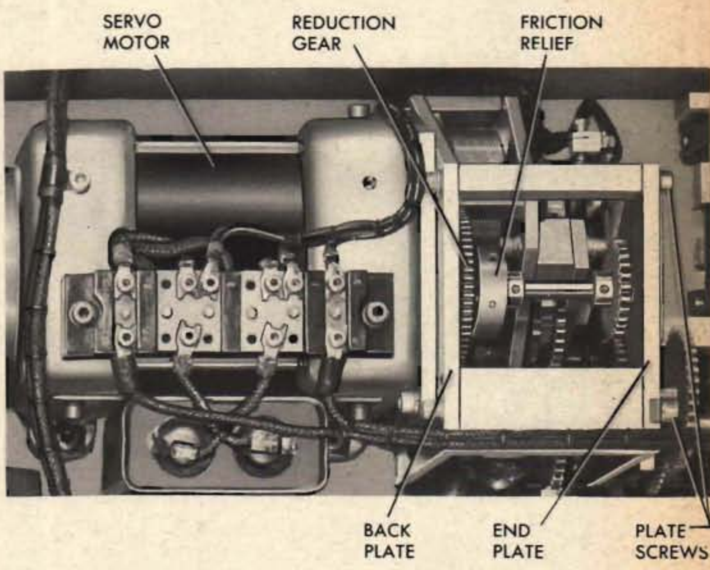
A servo motor drives through a reduction gear meshed with a pinion on the end of the rotor shaft. The reduction gear is usually mounted between two friction rings. A metal cap pinned to the drive shaft is drilled to hold six coil springs which press the friction rings firmly against the reduction gear. Dowels prevent the metal cap and the friction ring from turning separately. The friction relief will transmit any normal load, but when the load on the shaft line is too great, or when a limit stop is reached, the friction relief slips against the reduction gear.



The reduction gear and friction relief assembly may be mounted in a housing attached to the motor end cap, but it is usually mounted in the open with other gearing. A housed-type reduction gear and friction relief assembly can be removed from the motor by taking out the two long screws which hold the housing to the frame.

An open-type reduction gear and friction relief assembly can be removed by taking out the screws which hold the end plate, removing the plate, and carefully pulling the unit out of the bearing in the back plate.

Reduction-gear and friction-relief assemblies vary in size and construction details, but the maintenance problems are similar.



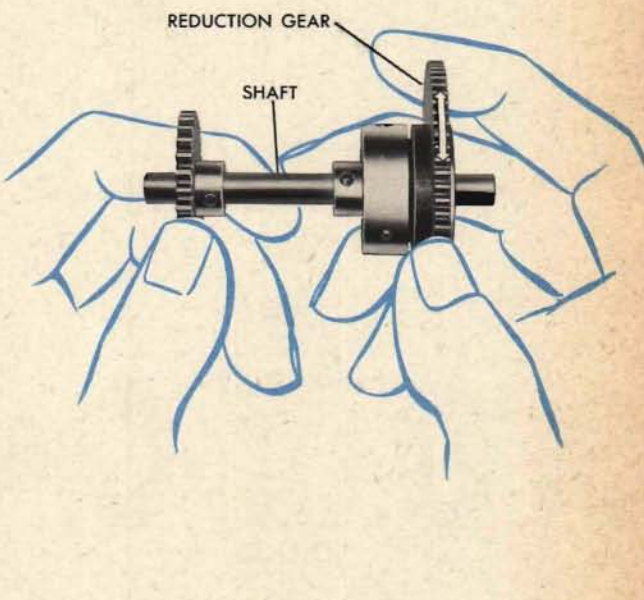
Typical symptoms

If trouble analysis of an instrument indicates faulty operation of a friction-relief and reduction-gear unit, look for one or more of the following typical symptoms:

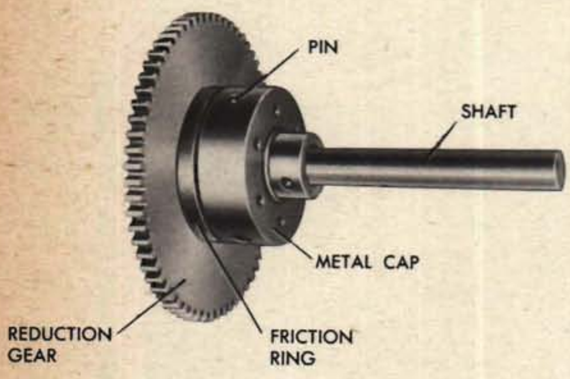
JAMMING: The reduction gear cannot be turned by hand when the shaft is held.

STICKING: The reduction gear does not turn smoothly when the shaft is held.

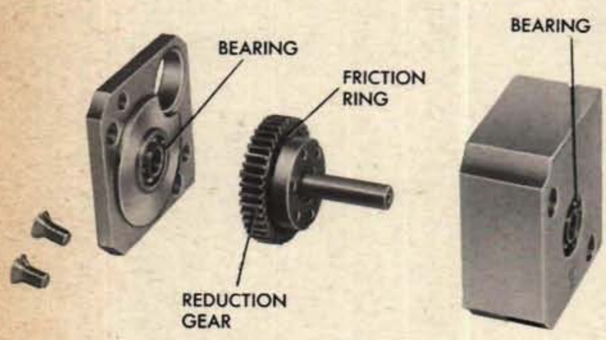
SLIPPING: The reduction gear slips on the friction ring when the load on the line is normal.



Locating the cause and repairing the parts

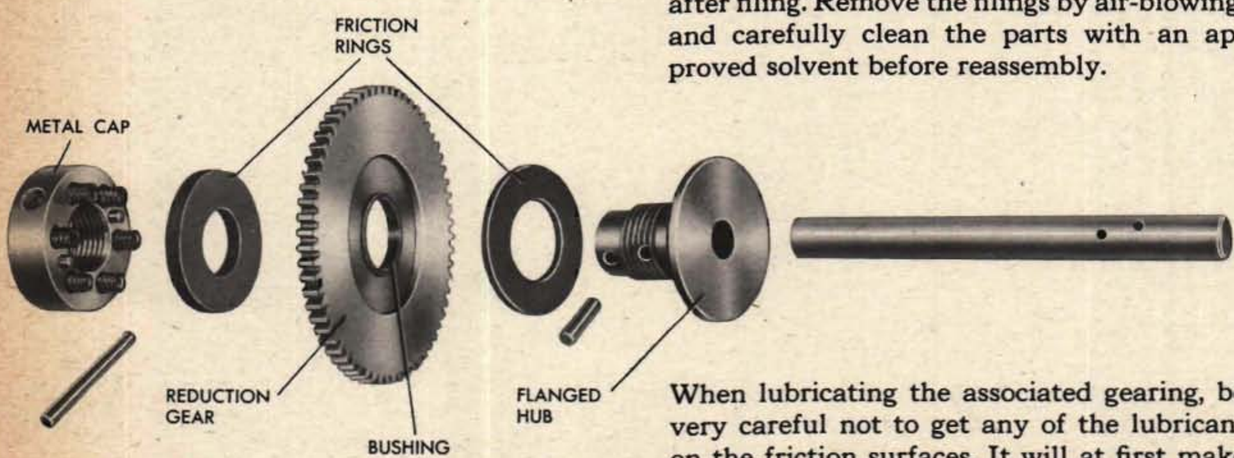


The friction is properly adjusted and its metal cap pinned to the shaft at the time of manufacture. If worn parts are replaced making readjustment necessary, the metal cap must be repinned. As the torque setting varies for different units, consult the assembly drawing for the correct value.



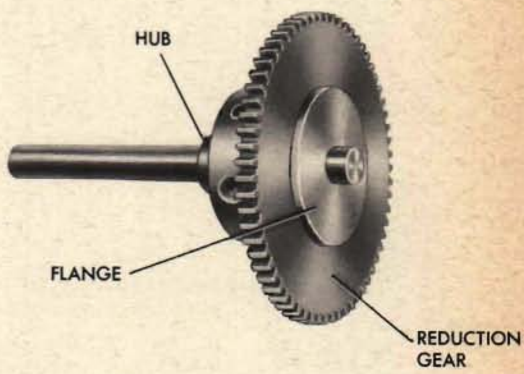
JAMMING OR STICKING of the reduction gear may be caused by dirty or damaged gears or bearings. Jamming or sticking of the friction may be caused by dirty or damaged friction surfaces, a reduction gear frozen to the flanged hub, or improper adjustment of the cap.

Dirty gears or bearings should be cleaned, and damaged ones replaced. The unit must be completely disassembled in order to clean dirty friction surfaces and to repair or replace damaged parts. Use a fine file to remove any roughness on the metal friction surfaces or to remove "glaze" on the non-metal friction surfaces. To insure uniform torque, make sure that the filed parts are of uniform thickness after filing. Remove the filings by air-blowing, and carefully clean the parts with an approved solvent before reassembly.



When lubricating the associated gearing, be very careful not to get any of the lubricant on the friction surfaces. It will at first make the reduction gear slip too freely, but later it will form high spots and make the reduction gear stick intermittently.

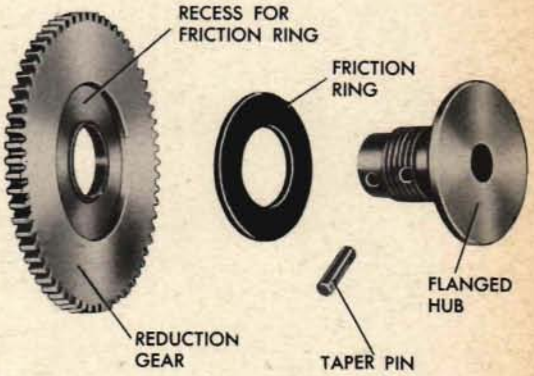
If the reduction gear and bushing are frozen to the flanged hub, disassemble the unit for repair. Use a fine oilstone to remove any nicks on the hub or on the inside surfaces of the gear. Keep trying the gear on the hub until it can be turned freely. Separate and clean the parts. Apply a very thin coating of approved lubricant to the bore of the bushing and reassemble the unit.



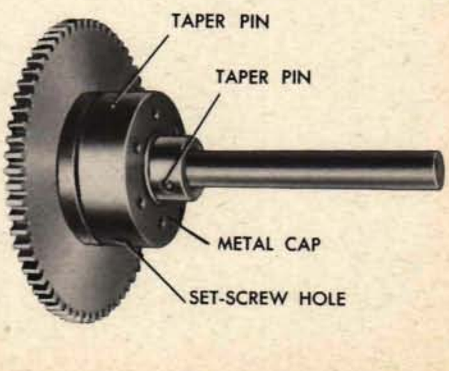
JAMMING of the friction may be caused by improper adjustment of the metal cap. See page 436 for the proper method of adjusting and testing a friction.

Slipping of the reduction gear when the torque on the shaft is normal may be due to a missing taper pin or to improper adjustment of the friction.

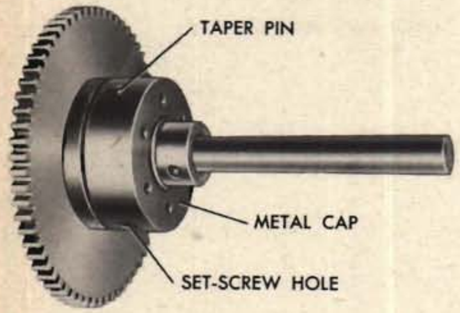
If a taper pin through the metal cap is not staked after reassembly, it may fall out, thereby allowing the metal cap to back off. This would weaken the friction and cause slippage.



Improper adjustment of a friction may result from failure to follow explicitly the directions for measuring torque as given on page 436 under "Adjusting the friction." The string by which the spring balance is attached to the long brass set screw in the metal cap must be kept perpendicular to *both* screw and shaft while measuring the friction torque or a deceptively high reading will be obtained.



Adjusting the friction



If it is suspected that a friction is too tight or too loose because of improper adjustment, the following procedure may be used to test the friction and obtain in inch-ounces the value at which it slips.

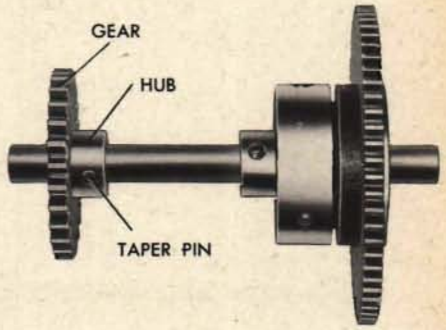
Insert a long brass screw in the set-screw hole of the metal cap. Place the gear in a vise between two wooden blocks, making sure that the vise will not interfere with the rotation of the metal cap. Now attach a spring balance, graduated in ounces, to the brass screw by means of a string. Holding the balance at right angles to both the screw and the shaft, exert sufficient pull to cause the shaft to rotate. As the shaft rotates, the balance must be kept at right angles to the screw and the shaft and the pull maintained as constant as possible. Read the values on the balance at intervals. They should be nearly equal for all points. The average reading in ounces, multiplied by the distance in inches between the center of the shaft and the point where the balance is attached to the screw, gives the torque in inch-ounces.

If the check shows that the torque is not within the limits given on the assembly drawing, the friction must be readjusted. Since readjustment requires that the metal cap be rotated in relation to the flanged hub and shaft, the taper pin will no longer go through all of the parts. To avoid having intersecting pin holes in the shaft, the flanged hub and shaft should be replaced.

To adjust for the proper torque, turn the cap to increase or decrease the friction. The long brass screw can be tightened so that it acts as a set screw while testing the torque and later while drilling and reaming the taper-pin hole. Refer to pages 63-65 for directions on pinning.

Disassembling the unit

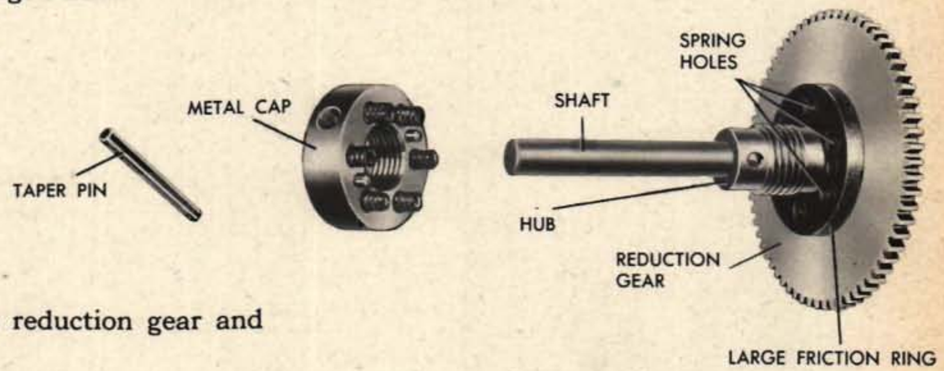
1 Drive the taper pin out of the hub and remove the gear on the end of the shaft.



2 Drive the taper pin out of the metal cap.

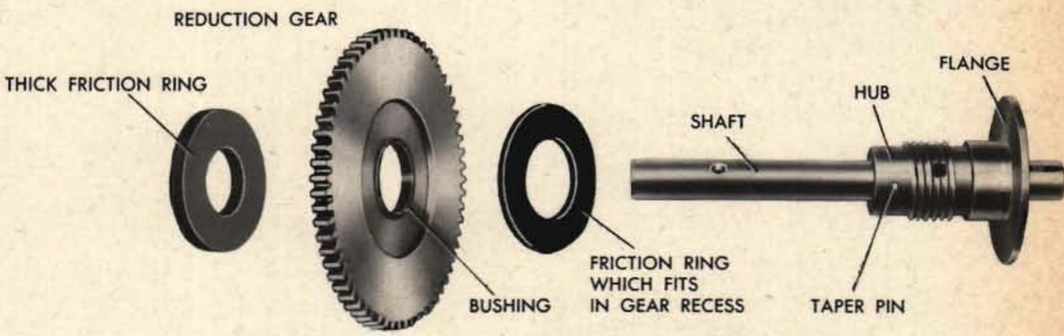
3 Unscrew the cap. The springs will come out with it.

4 Remove the large friction ring from the flanged hub.

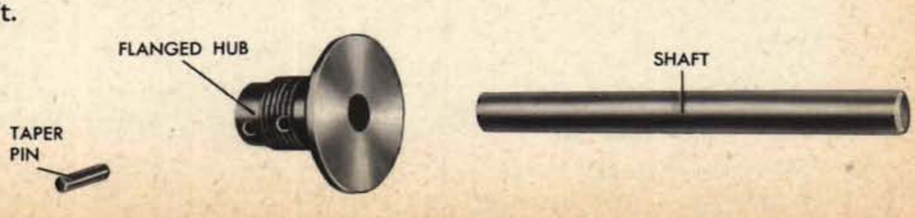


5 Remove the reduction gear and bushing.

6 Take the small friction ring out of the recess in the gear.

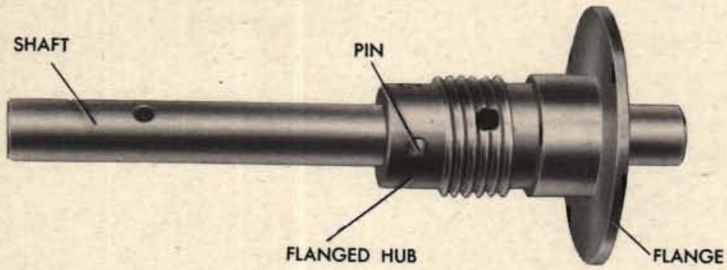


7 Drive the taper pin out of the flanged hub and remove the hub from the shaft.

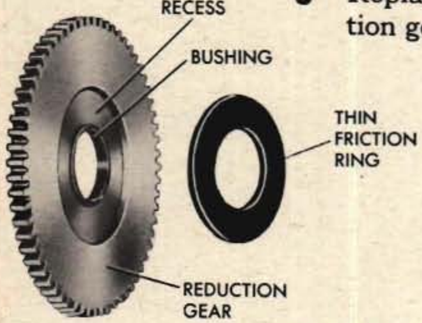


Reassembling the unit

1 After making sure that any burrs on the shaft or hub have been removed by polishing, pin the flanged hub to the shaft.

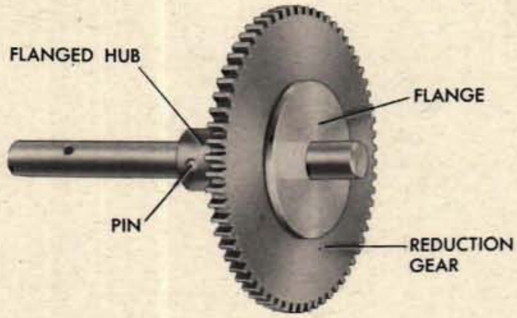


2 Put the bushing in the hole in the gear.



3 Replace the thin friction ring in the recess of the reduction gear.

4 Mount the reduction gear with its recessed surface facing the flange.



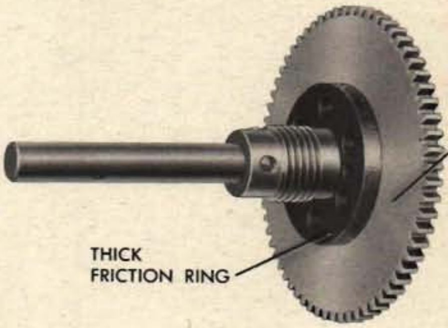
5 Replace the thick friction ring with the spring holes facing away from the gear.

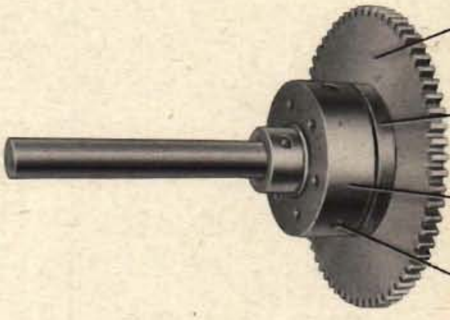
6 Replace the metal cap and springs. Be sure that the springs are properly seated in the cap and that the dowels are properly seated in the holes of the friction ring.

7 If a new flanged hub and shaft are used, adjust the friction to the value specified on the assembly drawing, following the procedure described on page 436. Insert and tighten a set screw in the metal cap.

8 Pin the cap to the shaft with the long taper pin. Remove the set screw.

9 Mount the gear on the other end of the shaft and pin it.



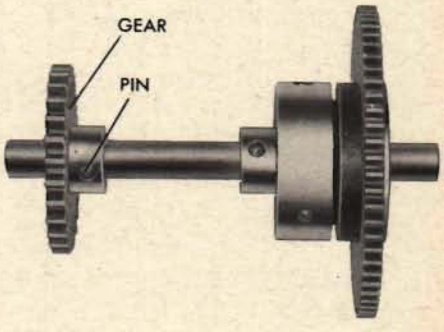


Bench checking the unit

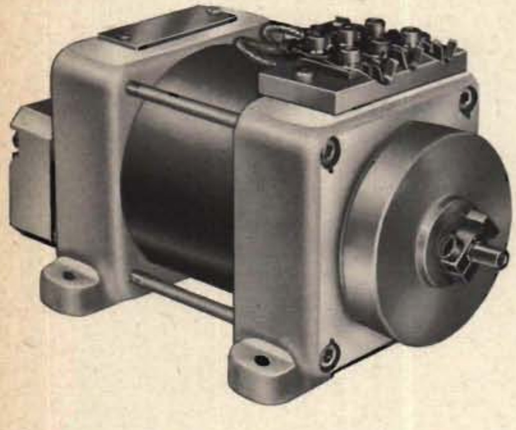
1 The unit should be assembled according to the assembly drawing.

2 The friction must be set for the correct torque. Refer to the assembly drawing for the value.

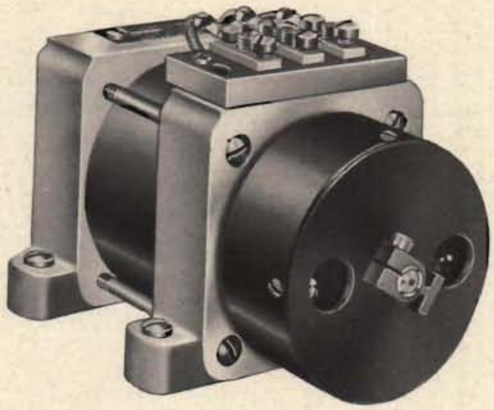
3 When the shaft is held and the gear is turned, the reduction gear should slip smoothly.



DAMPERS



MAGNETIC DAMPER ATTACHED
TO SERVO MOTOR SHAFT



MECHANICAL DAMPER ATTACHED
TO SERVO MOTOR SHAFT

A damper aids in controlling a follow-up by reducing surges in the shaft line. Dampers enclosed in synchro motors are discussed at the end of the chapter on the synchro motor. The dampers discussed in this chapter are used on servo-motor shaft extensions.

Two types of dampers, magnetic and mechanical, are commonly used with servo motors. Either type can be removed easily by loosening an assembly clamp on the split hub which holds the unit on the servo motor shaft.

The magnetic damper consists of a magnetized rotor enclosed in a case.

The mechanical damper consists of two inertia-type friction brakes enclosed in a case.

A faulty damper may be a cause of follow-up trouble.

Typical symptoms

A faulty damper is usually detected when the follow-up is in operation. Symptoms of trouble which may be caused by both types of damper are discussed in detail in the chapter on the follow-up, page 402. If the trouble indicates a faulty damper, remove the damper and examine it for one or more of the following typical symptoms.

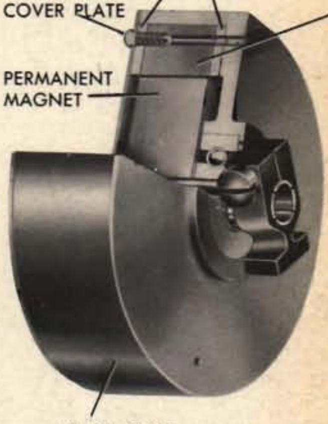
JAMMING: In either unit, the rotor cannot be turned independently of the case.

STICKING: In either unit, the rotor resists turning past certain points. In a mechanical damper the rotor may turn sluggishly.

SLIPPING: In either unit, the rotor turns too freely within the case.

Repairing a magnetic damper

A magnetic damper is a simple unit which usually can be cleaned or remagnetized without disassembly.



Jamming or sticking

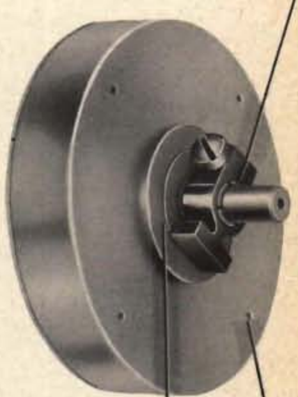
If the rotor and case jam or stick because of dirty bearings, it is possible but not advisable to wash the bearings without disassembling the unit. If this is done, every effort should be made to remove foreign matter which may be washed into the damper case itself. Further, be sure to remove *all* the solvent from the inside of the case before installing the damper. If dirty bearings are not the source of trouble, it is best to replace the unit. As a last resort, if no replacement is available, disassemble the unit to remove a broken rotor, damaged bearings, or foreign material between the rotor and the stator. After reassembly the unit must be remagnetized.

Slipping

If the rotor turns too freely within the case, the damper has lost some of its magnetism. To remagnetize it, place the entire unit in a d-c field generated by 40,000 to 60,000 ampere turns.

Disassembling a magnetic damper

If the unit must be disassembled to clean it or to replace a rotor or a bearing, be careful not to jar it, because magnetic damper rotors are extremely brittle. A cracked or broken rotor cannot be repaired.



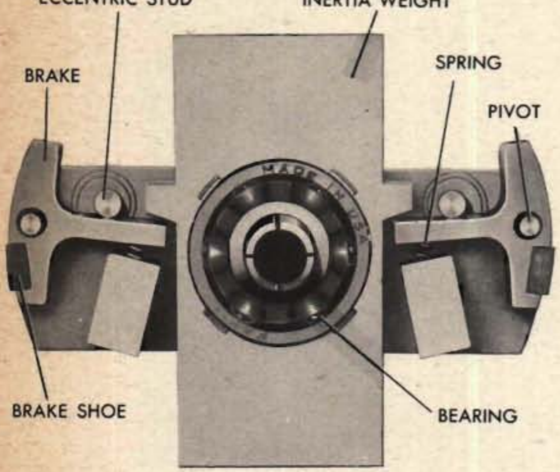
1 Remove the clamp and spacer from the split hub.
2 Knock out the drive screws and lift the case.
3 *If the case has only one bearing,* the snap ring on the split hub must be removed before the rotor can be lifted out. The single bearing is staked in place. It can be cleaned while it is seated in the case. If a new bearing is required, be sure to stake it to hold it in place.
4 *If the case has two bearings,* the rotor and the bearings can be lifted out easily. Tag the spacers so that they may be mounted in their proper relative positions after a bearing has been replaced.

Reassembling a magnetic damper

1 Follow the disassembly procedure in reverse order.
2 After reassembly, magnetize the entire unit in a d-c field generated by 40,000 to 60,000 ampere turns.

Repairing a mechanical damper

Usually a mechanical damper can be adjusted without disassembly, but most of the repair operations require disassembly.



WORKING PARTS OF A MECHANICAL DAMPER

Jamming or sticking

A brake may engage the case continuously or intermittently because of a frozen pivot, a weak or damaged spring, dirty or damaged bearings, foreign matter wedged between the brake and the case, or an improperly adjusted eccentric stud. Disassemble the unit to smooth the pivot, to replace the spring, to clean or replace the bearings, or to remove foreign matter. Bearings staked in place can be cleaned and lubricated with light oil without being unseated.

Slipping

A brake may fail to engage the case because of a frozen pivot, dirty or damaged bearings, or a worn, oily, or damaged brake-shoe surface. Disassemble the unit to smooth a frozen pivot, to clean or replace bearings, or to clean or replace the cork braking surface. To remove oil from cork, clean the surface with a suitable solvent. To mount a new braking surface, cut the cork to size and attach it to the brake shoe according to the method described on page 18.

Adjusting the unit

To adjust a damper, reposition both eccentric studs so that the case will turn freely.

1 Turn one stud so that the case is held by the brake.

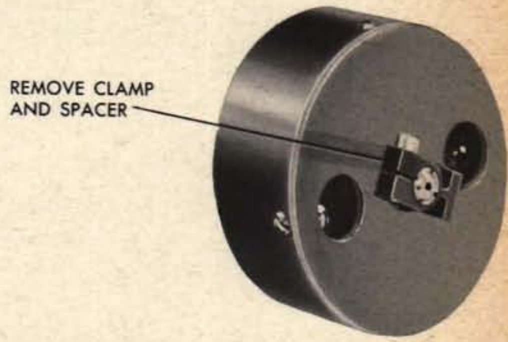
2 Turn the stud in the opposite direction until the brake just releases.

3 Repeat steps 1 and 2 on the other stud and brake.

The brakes should just clear the case when there is a small rotor acceleration, but should hold when the rotor is accelerated rapidly. The eccentric studs should be slip-tight.

Disassembling a mechanical damper

1. Remove the clamp and the spacer from the split hub.
2. Remove the cap and the spacer.
3. Lift out the rotor assembly, brake mechanisms, and spacer.
4. Pull the inertia weight off the rotor shaft.



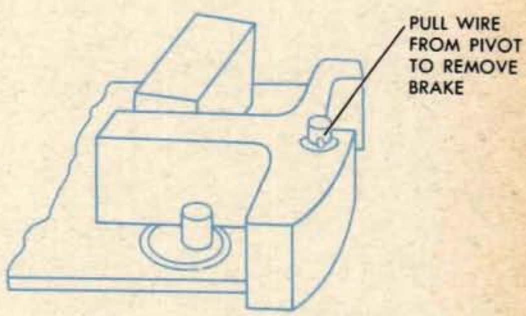
CAP

ROTOR ASSEMBLY

INERTIA WEIGHT

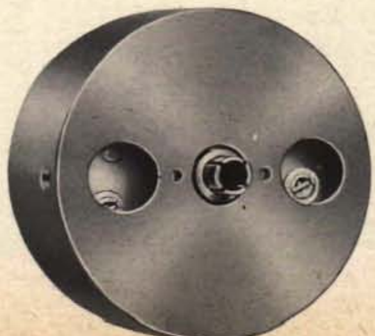
CASE

To remove the brake, pull the small copper wire out of the pivot. Staked bearings can be cleaned in place. Replace damaged bearings or springs.



Reassembling a mechanical damper

1. Stake the new bearings.
2. Follow the dissassembly procedure in reverse order.
3. When replacing the cap, line up the two large holes in the cap with the two large holes in the case.



THE SYNCHRO

This chapter is designed to assist the fire controlman in locating and remedying casualties to synchro units. If the fire controlman is not already familiar with the theory of operation, electrical and mechanical characteristics, and general construction of synchro units, he should first read the synchro section of OP 1140. A copy of OP 1303 should also be available as a reference.

Casualties involving "Ship's Wiring"

Synchro system casualties involving "ship's wiring" and the effects of multiple errors in connecting synchro units are thoroughly covered in OP 1303 and will not be repeated here. This chapter will treat the synchro unit rather than the complete synchro system.

Typical symptoms

The more common symptoms of casualties to synchro units are:

Jamming
Sticking
Erratic operation
Overheating

Locating the cause

Jamming

In most cases, jamming occurs after a synchro has overheated. Overheating causes the insulating varnish to decompose. The vaporized products of decomposition condense on the moving parts, causing the rotor to jam.

Jamming of the rotor of a synchro unit can be caused by improper mounting of the unit in its associated equipment.

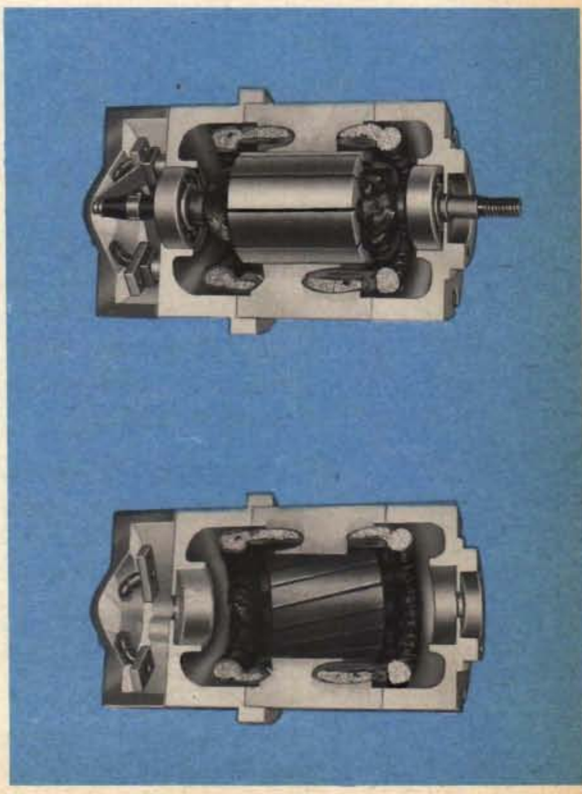
Sticking

Rough operation or sticking is usually caused by dirt, hydraulic fluid, or any foreign substance in the rotor bearings of a synchro motor. If the rotor does not turn freely, check that the rotor end shake is correct. See the assembly drawing for the correct tolerance for any particular unit. Also inspect the rotor bearings as specified in the chapter on *Shaft Lines*.

Erratic operation

Erratic operation is usually due to poor contact between brushes and slip rings. Slip rings should be examined for signs of excessive wear or eccentricity. Brushes making poor contact can be located with an ohmmeter.

CONTROL TRANSFORMER
MARK 5 MOD 3A
TYPE 1CT



Overheating

Excessive current flowing in the rotor or stator coils will cause overheating. Excessive current may result from restraint of a motor rotor, open rotor circuits in another connected synchro or in the external "ship's wiring," or improperly connected external wiring. For instructions on locating such troubles, refer to the trouble-shooting section of OP 1303.

Disassembling the unit

Most synchro units are disassembled in the same general manner. The disassembly of several representative units is evident from the accompanying exploded illustrations; however, there are certain precautions that should be observed.

Care must be taken at all times to keep the various parts of the synchro clean, especially the bearings, brushes, and slip rings. On the larger units, care must be taken to avoid bending the brush supports when removing the rotor from the stator. In the case of those units that are equipped with the shoe-type, silver graphalloy brushes, the brush rigging should be removed from the unit before the rotor is removed.

Repairing the damaged part

If a synchro requires major repairs, it is recommended that it be replaced. Since all Mods of a given size and type synchro are in most cases interchangeable, a check of the spare parts for all ordnance equipments should be made before attempting to make synchro repairs. However, if no spares are available, and the operational demands of the ship require that the synchro function, emergency repairs will have to be made. A synchro unit which has undergone major shipboard repairs should be replaced at the first opportunity.

If the insulating material has broken down enough to cause "shorts" in either the rotor or the stator, the defective part will have to be wholly or partially rewound. The size and number of turns of wire required may be obtained by examination of the damaged part.

Dirty bearings, burred or bent shafts, and similar mechanical casualties should be reworked in accordance with the instructions in the chapter on *Shaft Lines.*

Rough spots on slip rings should be smoothed with fine crocus cloth or French paper. The slip rings should not be burnished because this causes high and low spots which interfere with the brush contact at high speeds.

SYNCHRO GENERATOR
MARK 3 MOD 3
TYPE 7G

END CAP

END-SHAKE
LIMITING SPACER

BEARING SPRING

BEARING OUTER RACE

BEARING BALLS AND
INNER RACE

ROTOR

STATOR

BEARING BALLS AND
INNER RACE

BEARING OUTER RACE

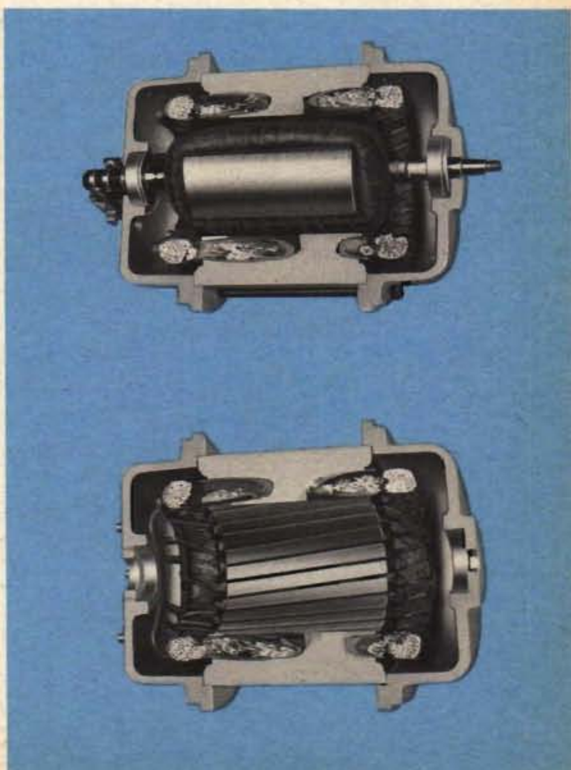
END CAP

WIRE CLAMP GRIP

BRUSH RIGGING

WIRE CLAMP
COVER

BRUSH RIGGING
COVER



The rotor end shake in the Mod 3 units is adjusted by varying the size of a spacer. Since the location of this spacer is different for each frame size, reference should be made to the pertinent assembly drawing.

Thorough cleaning usually will eliminate sticking of dampers. If it becomes necessary to replace the damper bearing, care should be taken to see that it turns freely after it has been staked into the damper flywheel.

Reassembling the unit

In general, the procedure for reassembling synchro units is the reverse of disassembly. Sufficient information can be obtained from the exploded illustrations. However, certain precautions should be observed. Make sure that the bearing at the slip-ring end of the rotor is positioned so that it will counteract thrust towards the slip-ring end of the rotor. Make sure that all motor rotor bearings are clean and turn freely. The slightest stick in a motor rotor bearing will cause an error in the rotor position because there is very little torque on the rotor when it is nearly in agreement with the signal from the transmitter. Make sure that all snap rings are properly seated so that they will not become loose when subjected to vibrations. When installing a synchro end cap, tighten the holding screws evenly. On synchros having shoe-type graphalloy brushes, the brush rigging should not be installed until the rotor is in place. Lubricating instructions for synchro units are contained in OP 1303.

Bench checking the unit

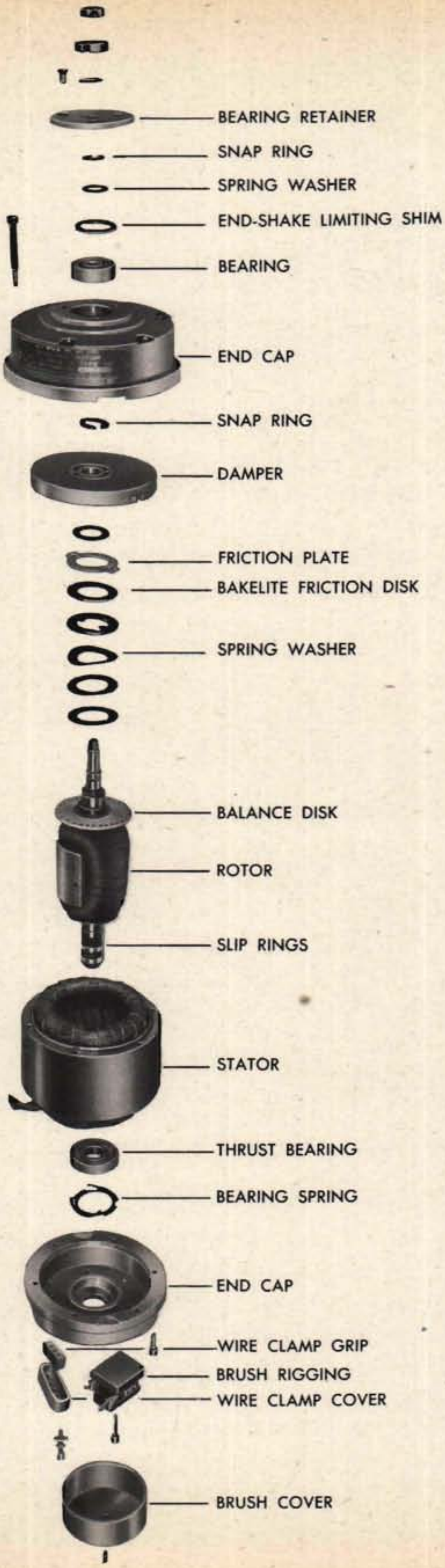
With an ohmmeter:

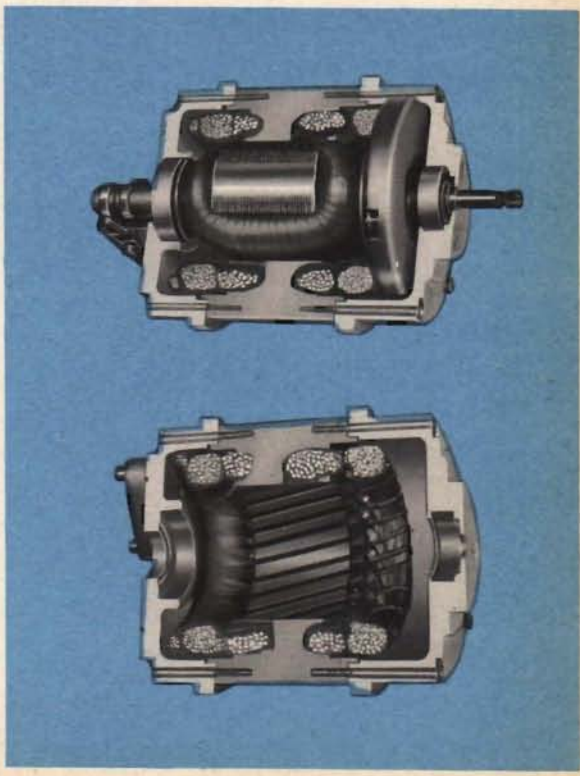
1 Check the d-c resistances between S1–S2, S1–S3, and S2–S3 pairs of terminals. They should be equal to each other and approximately equal to the value given in the characteristics section of OP 1303.

2 Check the d-c resistance of the rotor winding. It should be approximately equal to the value given in OP 1303. Check to see that this value does not vary as the rotor is turned slowly.

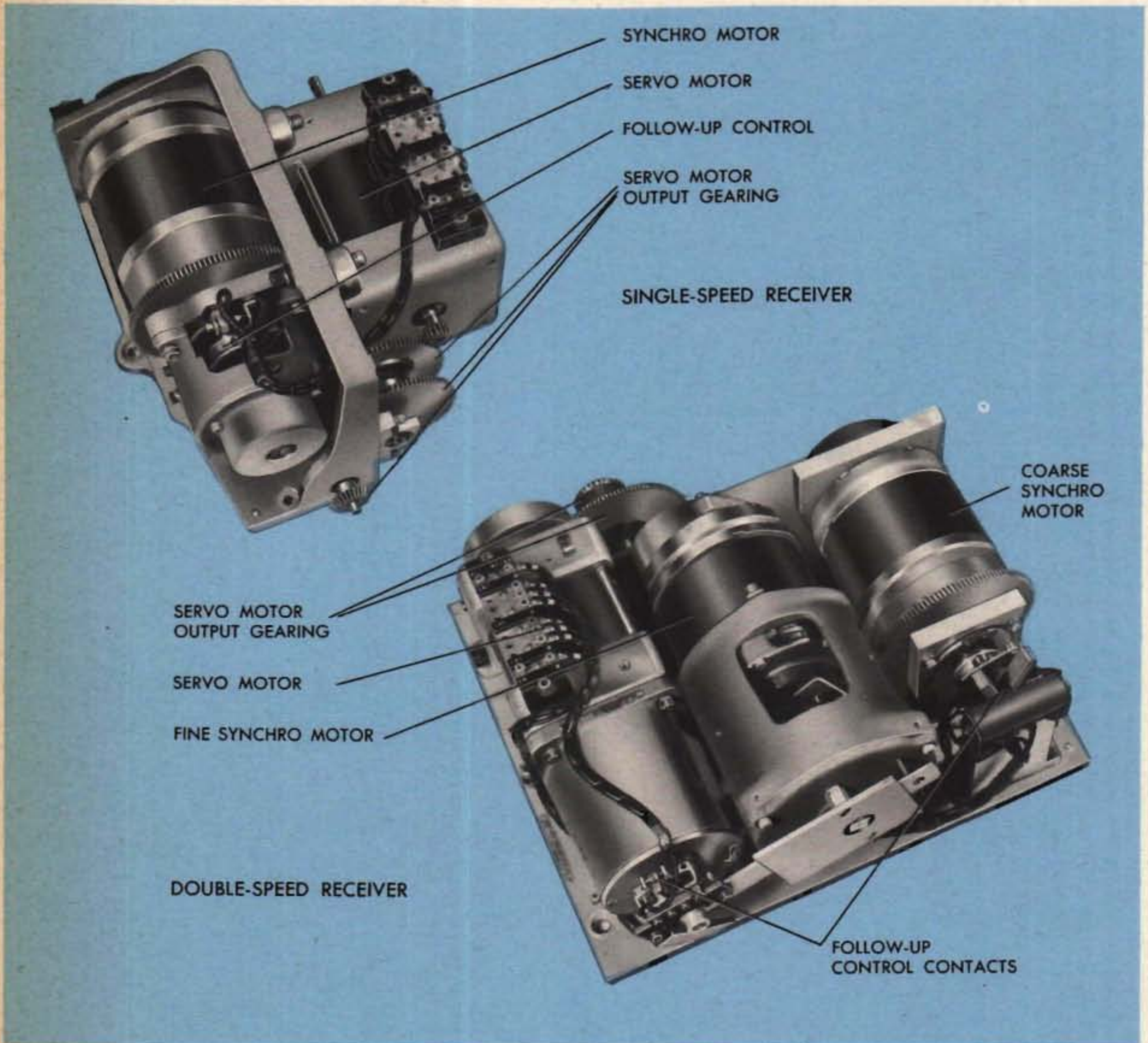
If the unit being tested is a synchro motor, connect it to a generator and make sure that it follows movements of the generator smoothly. De-energize the motor and displace the rotor approximately 179 degrees. When the motor is energized, it should come into synchronism with the generator without oscillating excessively.

SYNCHRO MOTOR
MARK 4 MOD 3
TYPE 5F





SYNCHRO RECEIVERS



A synchro receiver combines a follow-up with one or two synchro motors so that synchro signals of low torque are amplified by the servo motor to drive heavily loaded shafts.

Indicating synchro receivers, which are made up of synchro motors and dial assemblies, are not considered as basic mechanisms in themselves. See *The Synchro,* page 444, and *Dial Assemblies and Counters,* page 136.

This chapter is concerned only with single-speed and double-speed *automatic* synchro receivers.

A single-speed receiver may be used to register either large changes with low accuracy or small changes with great accuracy. A double-speed receiver can accurately register both large and small changes.

A single-speed receiver consists of a bearing-mounted synchro motor, a follow-up control, and a servo motor. These three units, mounted on a frame and connected by shaft lines, make up the unit.

A double-speed receiver consists of two synchro motors, one fine and one coarse, a follow-up control, and a servo motor. These units, mounted on a plate and connected by shaft lines, make up the unit.

The synchro motors receive the electrical input signal. The follow-up control switches the signal from the synchros to the servo motor. The servo motor amplifies the signal and drives the output gearing in response to the input signal.

In several types of receivers, the details of follow-up control design and the arrangement of units differ from those described and illustrated in this chapter. In general, however, directions given here can be applied to all the other receivers except range receivers. Since the construction of range-receiver contacts may be different for each unit, range receivers are described in the various instrument OP's.

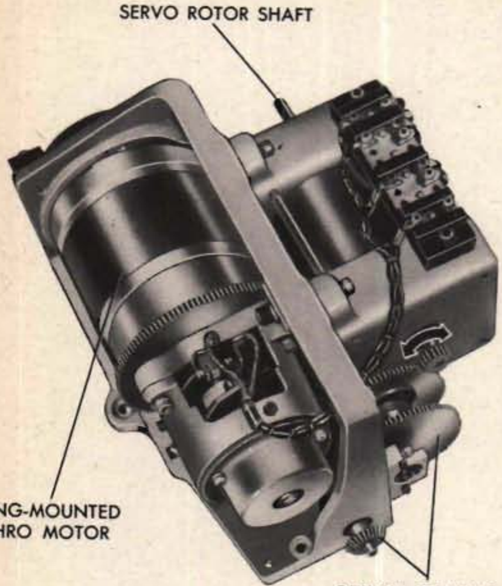
If the operation of a receiver is known to be faulty, first clean the parts as well as possible and inspect the unit. The decision to repair the unit in place or to remove it from the instrument depends on the location of the unit within the instrument and whether the difficulty is of minor or major importance.

The typical symptoms and the procedure for locating the cause are similar for both single- and double-speed receivers.

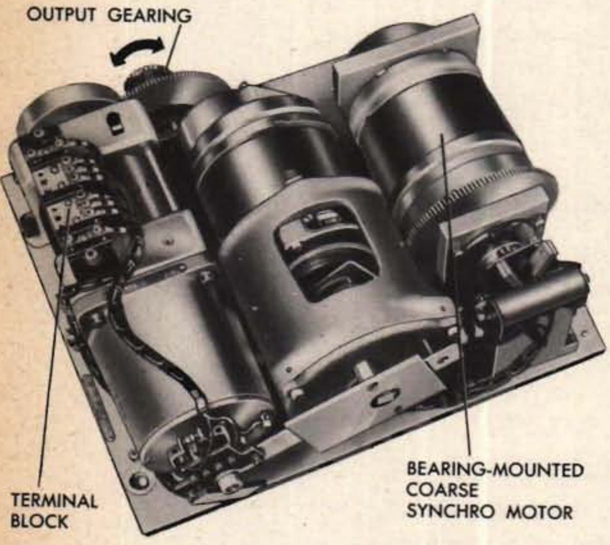
Typical symptoms

If a test analysis and unit check test indicate that the servo motor in a synchro receiver does not follow the synchro input signal normally, look for one or more of the following typical symptoms:

FAILURE TO RUN: The output does not turn.
RUNNING AWAY or DRIFTING: The servo motor runs constantly or drifts off from a synchronization point.
ERRATIC OPERATION: The output may be rough or sluggish, may jiggle, hunt, follow in only one direction, or synchronize at more than one point for a fixed synchro input signal. The double-speed unit may also buck.
NOISE and HEAT: The unit operates noisily or is overheated.



SINGLE-SPEED RECEIVER



DOUBLE-SPEED RECEIVER

Locating the cause

Failure to run

If the servo motor does not turn, the servo output does not follow the synchro input signal, or the receiver synchronizes or tends to synchronize at only one point, the trouble may be:

Jammed gearing
Dead servo motor
Slipping parts
Locked synchro rotor

Jammed gearing

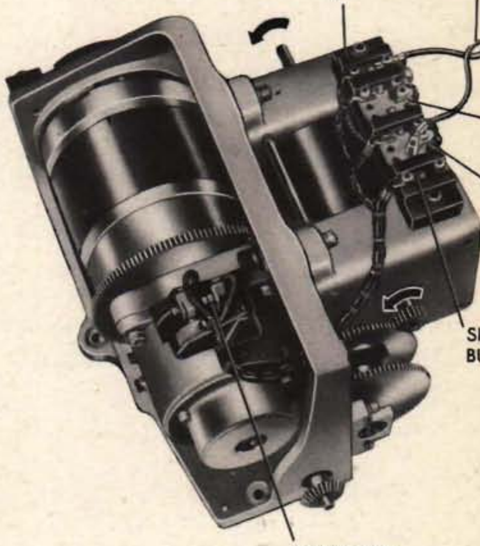
With the power OFF, try to turn the output gearing by hand. Inspect the unit for dirty or damaged gears and bearings, and for foreign material or interference between moving parts. If the rotor of the servo motor is jammed, the servo must be repaired or replaced. For directions on repairing a servo motor, refer to page 426.

The synchro of the single-speed unit and the coarse synchro of the double-speed unit, which are bearing-mounted, are also part of the shaft line.

Dead servo motor

A servo motor may not operate because of an open circuit in the receiver wiring or because the servo motor or the capacitor has become defective.

BY-PASS TEST

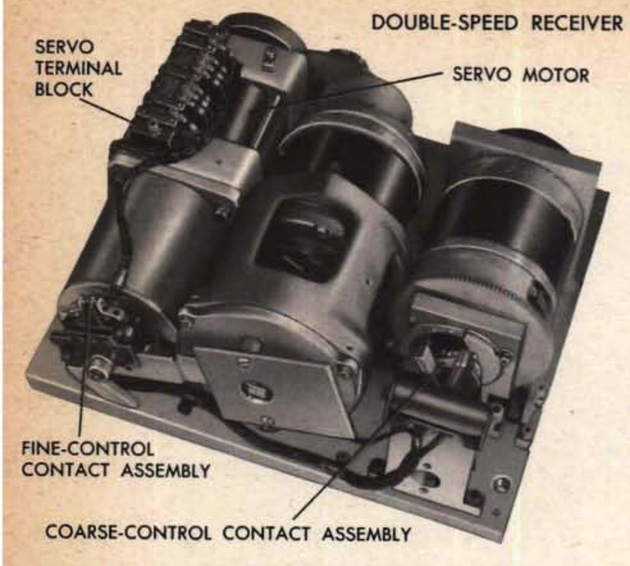


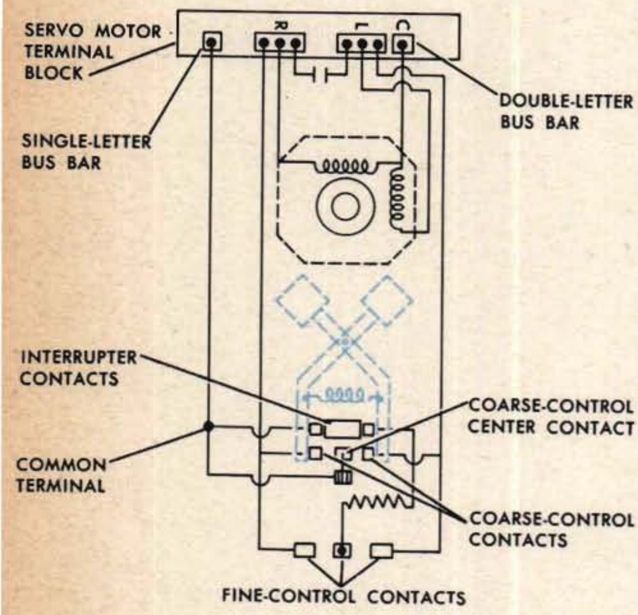
If the motor does not operate when the follow-up contacts are displaced, make a by-pass test to check whether the trouble is in the servo and capacitor or in the receiver circuits. To do this, remove the power lead from the single-lettered bus bar on the terminal block. Touch this lead to the bus bar marked "R" or "L." This should cause the motor to run. *Do not touch the terminal marked "C,"* or a short circuit will result.

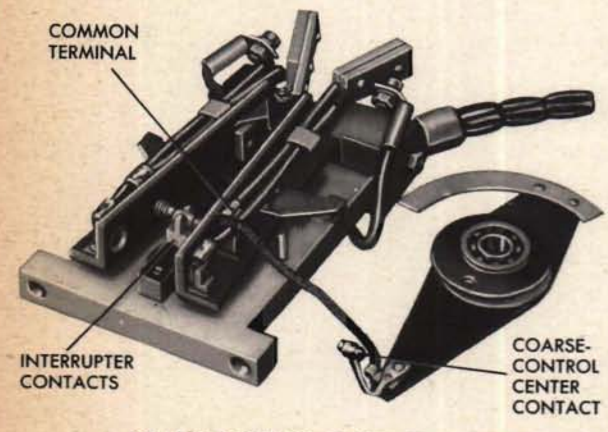
If the motor runs when the single-letter lead is touched to L or R, the trouble is probably due to either an open in the receiver pigtail wiring or dirty or damaged contacts. Replace faulty pigtails and terminals lugs. Contacts which are not badly worn may be removed and resurfaced. Burned or deeply pitted contacts should be replaced.

If the motor does not run under the by-pass test, the trouble may be one of three things: a faulty capacitor, an open or short within the servo stator, or a short between the R and L stator circuits.

Check for a faulty capacitor by trying a new one. To check for a defective servo motor or a short between the R and L stator circuits, remove pigtail terminals 1 and 2 from the motor terminal block and repeat the by-pass test. If the motor now runs under this by-pass test, there is probably a short across the R and L leads caused by defective pigtail wiring or by the contacts being too close together. If the motor still does not run, the trouble must be in the motor itself. For instructions on repairing the servo motor, see page 426.







COARSE-CONTROL CONTACT ASSEMBLY

Determine whether the servo motor of the double-speed receiver will operate in fine control by offsetting the fine-control contacts, and in coarse control by offsetting the coarse-control contacts.

If the servo does not operate in either fine or coarse control, the trouble is probably due to an open circuit between the servo terminal block and the common terminal.

If the servo will not operate in coarse control but operates in fine control when the interrupter contacts are closed, the trouble may be an open circuit between the common terminal and the coarse center contact.

If the servo will not operate in fine control but operates in coarse control, there is probably an open circuit between the interrupter contact and the fine center contact.

An open circuit may be caused by a loose connection or a broken wire and can often be repaired in place.

Slipping parts

If the servo motor turns but the output does not follow the input signal, the trouble may be caused by a loose friction relief, an unpinned gear, or a loose clamp. Instructions for the repair of frictions are given on page 434. The assembly drawing gives data for setting the frictions. An unpinned gear may usually be repinned in place.

Locked synchro rotor

If a single-speed receiver remains synchronized at one point only or a double-speed receiver synchronizes or tends to synchronize at one point only, the trouble may be caused by a locked synchro rotor.

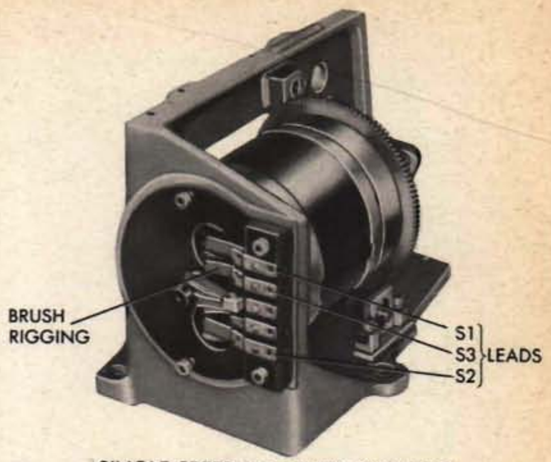
On the double-speed receiver, locking may also be accompanied by bucking. Refer to page 459.

If the rotor is free to turn when the synchro power is OFF and is locked when a varying input is applied with the power ON, the trouble may be caused by a short circuit between the S leads. Check the external electrical connections to the synchro.

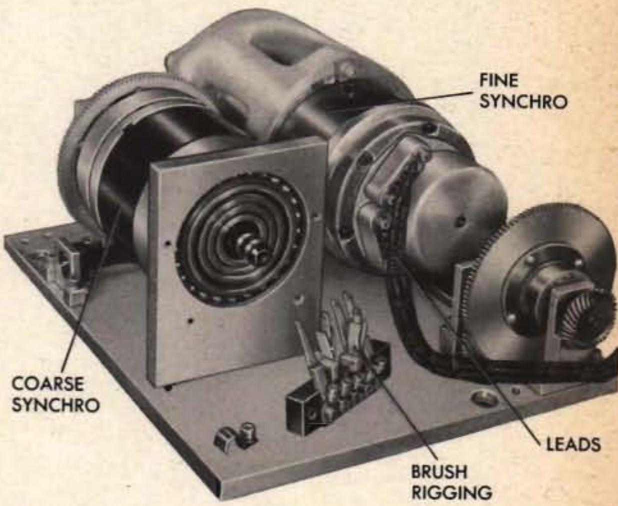
On the single-speed unit, look for damaged brush rigging or foreign objects which may be short-circuiting the leads.

On the double-speed unit, look for damaged brush rigging in the coarse synchro and bare leads on the fine synchro. If a fine synchro lead is broken, replace the synchro if possible. Otherwise splice the lead and wrap the splice with insulating tape.

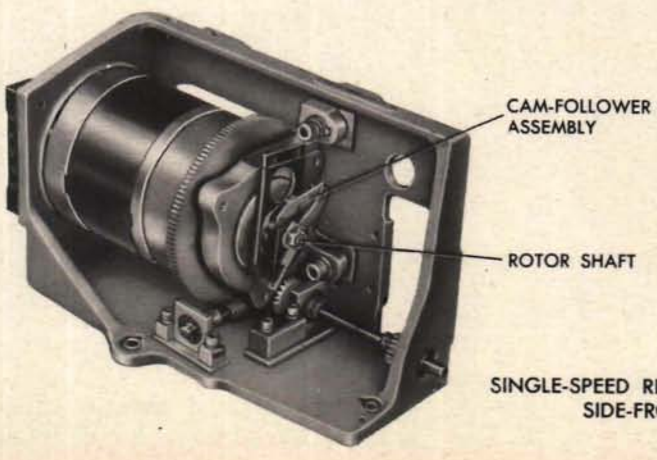
If the rotor is locked when the synchro power is OFF, the trouble may be caused by mechanical jamming of the rotor. Dirty or damaged bearings, a burned-out synchro, interference with the cam-follower assembly, or a bent part may be the cause.



SINGLE-SPEED RECEIVER SYNCHRO
REAR VIEW

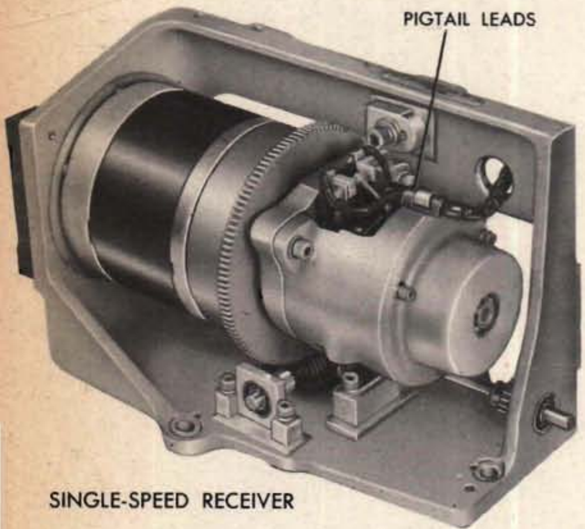


DOUBLE-SPEED RECEIVER SYNCHROS
REAR VIEW



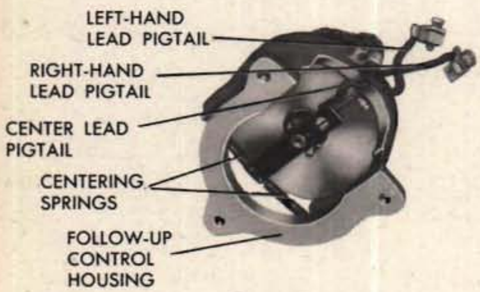
SINGLE-SPEED RECEIVER SYNCHROS
SIDE-FRONT VIEW

Runaway output



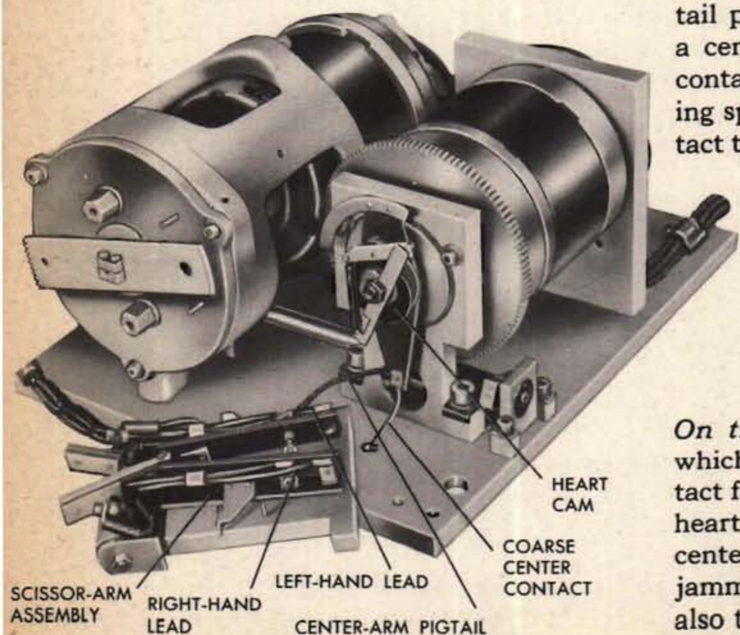
SINGLE-SPEED RECEIVER

If the servo motor turns constantly in one direction regardless of the synchro input signal, the trouble may be caused by a short circuit between the center pigtail and either the right or left-hand pigtail in a single-speed unit, or between the center pigtail and right or left-hand pigtail of the coarse control in a double-speed unit.



The same type of short circuit in the fine control of the double-speed unit would result in bucking. See page 459.

On the single-speed unit, look for a tight pigtail pulling the outside contacts to one side, a center contact jammed under an outside contact, a short circuit, or a missing centering spring which may permit the center contact to be pulled over to one side.



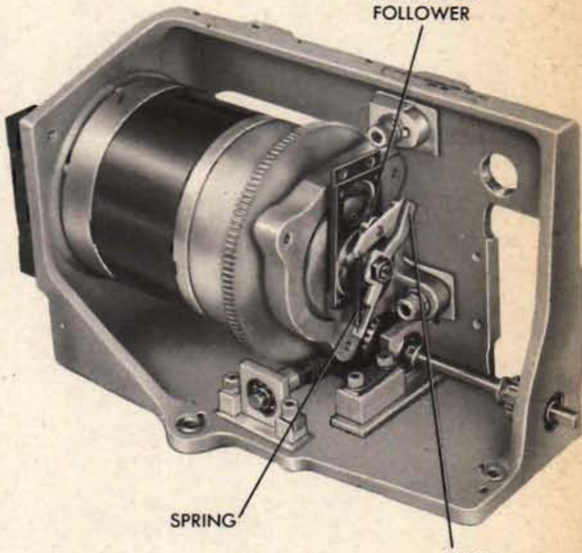
DOUBLE-SPEED RECEIVER SYNCHROS

On the double-speed unit, look for causes which would prevent the coarse center contact from responding to the movement of the heart cam. Check to be sure that neither the center contact nor the center-arm pigtail is jammed in the scissor-arm assembly. Check also to be sure that the center-arm pigtail is not short-circuited with the left or right-hand pigtail or contacts.

Drifting output

If the output of a single-speed unit creeps slowly, regardless of the input signal, check the synchro rotor torque. If there is normal torque, the trouble may be caused by a jammed pivot or a missing spring on the heart-cam follower.

If there is no torque, there is probably a broken connection between the terminal buses and synchro motor windings caused by broken, bent, or dirty slip rings or brushes.



SINGLE-SPEED RECEIVER SYNCHRO

Erratic operation

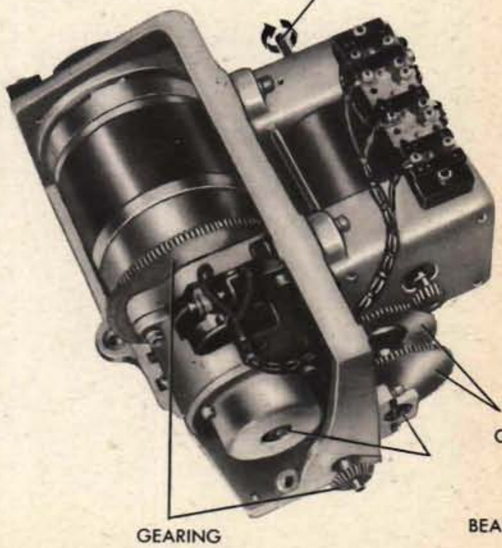
If the servo output does not follow the input signal normally, the trouble may be described as:

Rough output: Output does not follow signal smoothly.
Bucking: Fine and coarse contacts of double-speed unit oppose each other and cause the servo to drift in one direction and then drive back in the other direction.
Hunting: High-amplitude, low-frequency shaft oscillation.
Jiggling: Low-amplitude, high-frequency shaft oscillation.
Sluggishness: Servo output is too low.
Faulty synchronization: Receiver synchronizes at more than one point for a fixed input signal.

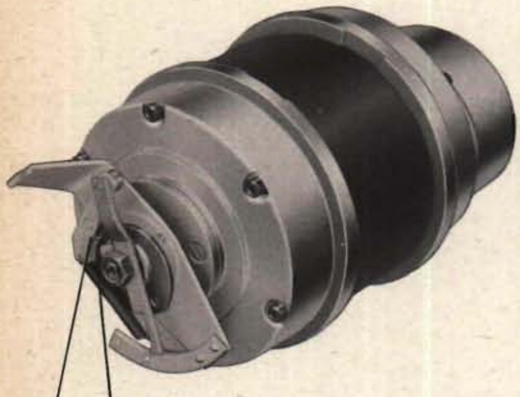
Rough output

A rough output may be caused by mechanical trouble in the shafting and gearing of the unit, or by mechanical or electrical trouble in a follow-up control or synchro.

With the power OFF, turn the shafts by hand and check for bent shafts and dirty or damaged bearings and gear teeth.

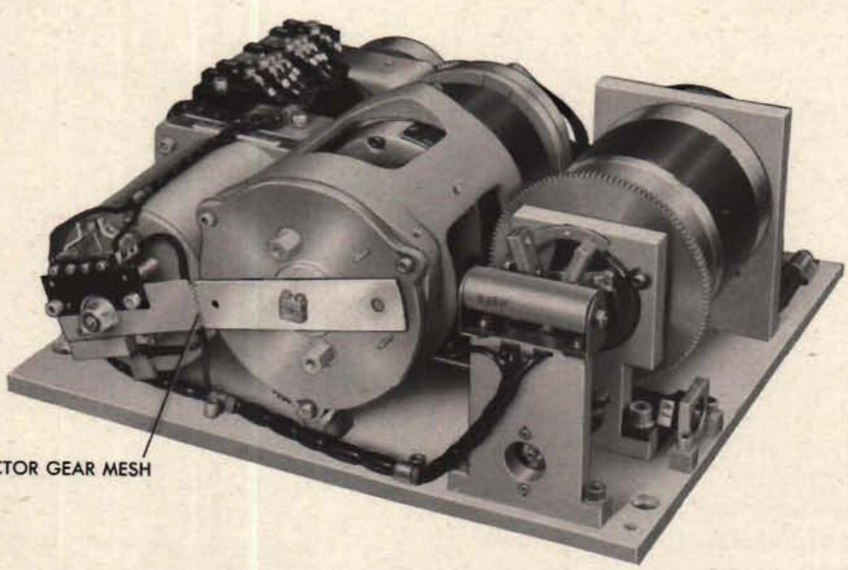


SINGLE-SPEED RECEIVER



Check the follow-up control thoroughly. Look for jamming or sticking in the follow-up control assembly or dirty or damaged contacts and bearings.

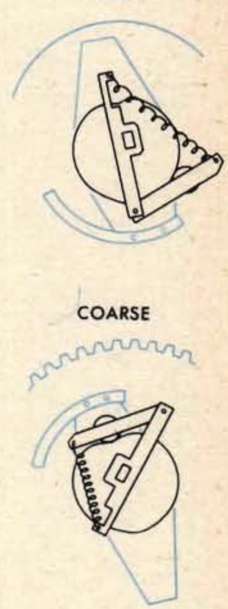
Sticky synchro bearings may cause the output to be rough. To check synchro bearings for sticking, disconnect the rotor shaft from the follow-up control and turn the rotor by hand, with the power **OFF**. The simplest way of doing this is to remove the spring from the heart-cam follower and move the rotor by means of the follower arm.



On the double-speed unit, look also for a dirty, damaged, or sticking sector gear mesh; interference with the sector arms or with the linking arm between the fine heart cam and the jewel differential; and incorrectly aligned or loose interrupter contacts or fine contacts. Sticking or binding in the jewel differential will also cause the receiver output to be rough. See the chapter *The Jewel Differential,* page 182, for the method of checking.

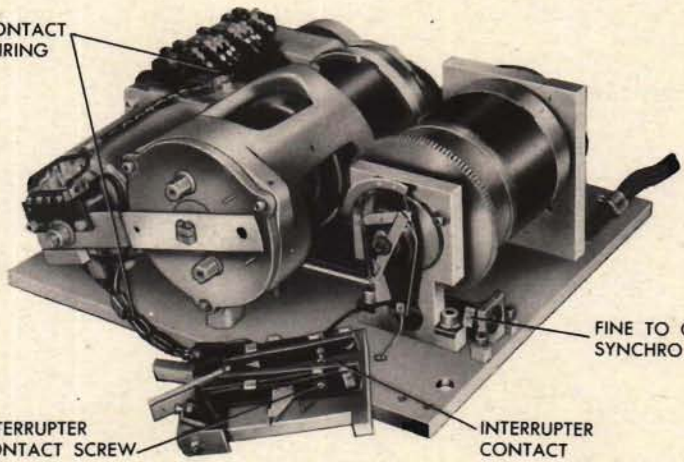
Bucking

Bucking occurs only in double-speed units. It results when the signals transmitted through the fine and coarse contacts oppose each other and cause the servo motor to drift off in one direction and then drive back rapidly in the other without synchronizing. When bucking occurs, it will be noted that the follower rollers are not in their respective heart-cam detents simultaneously.



Bucking may be caused by an improper adjustment between the synchro motors, improperly adjusted interrupter contacts, reversed rotation of a synchro rotor, incorrectly connected contact wiring, or by an open synchro stator lead.

In making a test for bucking, use a transmitter which has properly adjusted fine and coarse generators geared together in the same ratio as the receiver synchro motor. Connect the transmitter to the receiver and transmit a fixed signal. Energize the servo motor so that the receiver will attempt to synchronize. Note whether the receiver is unstable or bucks and observe the heart-cam followers. Repeat the test for different fixed signals because certain types of bucking do not occur at all synchro rotor positions. Turning the power OFF while the signal is being changed for each test will further aid in locating a position where the receiver bucks.



If the test shows that the receiver bucks, first determine whether improper adjustment between the fine and coarse synchros is causing the fine and coarse contacts to oppose each other. If the interrupter contacts have been screwed in too far, the follower of the fine heart cam will drive beyond the peak before the coarse-control center contact can open the scissor arms, break the interrupter contacts, and take control. This action also causes the fine contacts to oppose the coarse contacts. To adjust the fine and coarse synchros and the interrupter contacts, refer to pages 488-489.

To check for proper synchro rotation, de-energize the servo motor and transmit an increasing signal. Use the wiring diagram to check whether the rotors turn in the proper direction. If they do not, check the wiring to determine where the reversal has been introduced, and make the necessary corrections.

If bucking is due to an open synchro stator lead, it will be noticed that synchro rotor torque and direction of rotation vary during a revolution. Refer to the wiring diagram while checking the stator leads and connections.

To check for reversed servo contact wiring in the follow-up control, move the center contact to complete the circuit for an increasing signal and observe whether the motor shaft turns in the direction indicated by the wiring diagram.

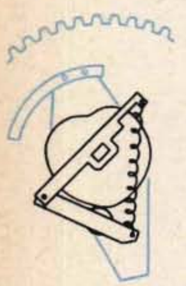
Hunting

FINE

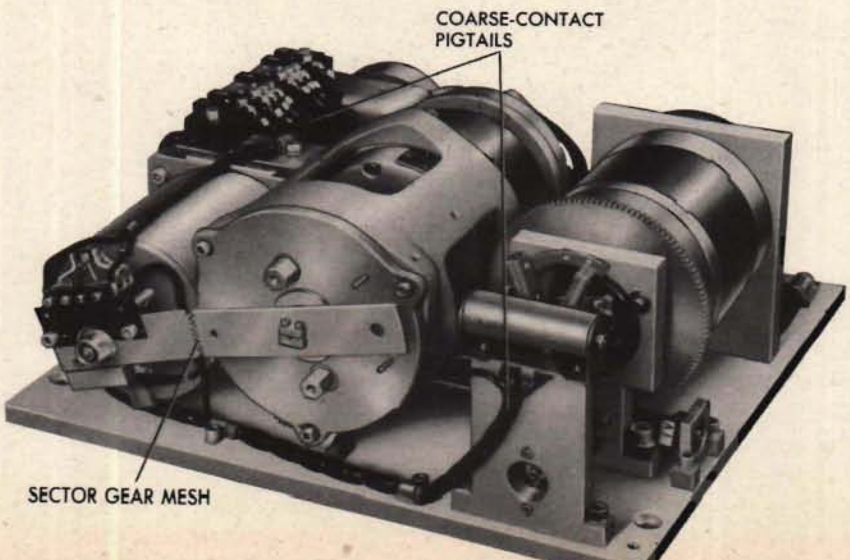
A receiver is hunting when, instead of synchronizing, it continues to drive back and forth through the synchronization point.

In the double-speed receiver, hunting may be caused by a reversal of the coarse-contact pigtails. This causes the receiver to hunt because the follower tries to position itself at the peak of the heart cam instead of in the detent. A tight sector gear mesh may also cause the double-speed receiver to hunt.

COARSE



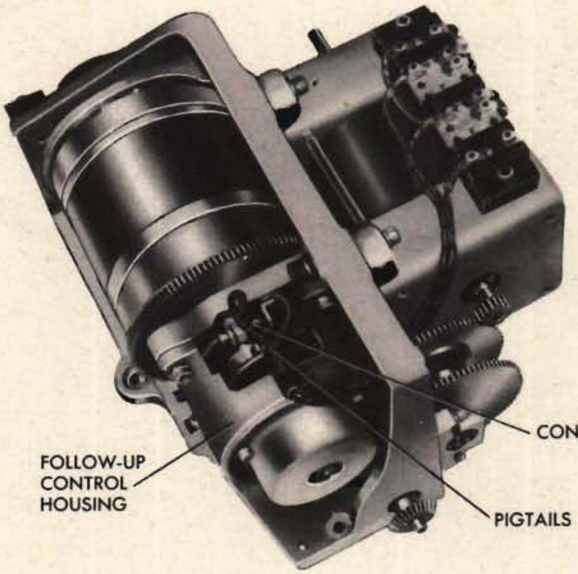
In the single-speed receiver, hunting may be caused by reversed contact wiring.

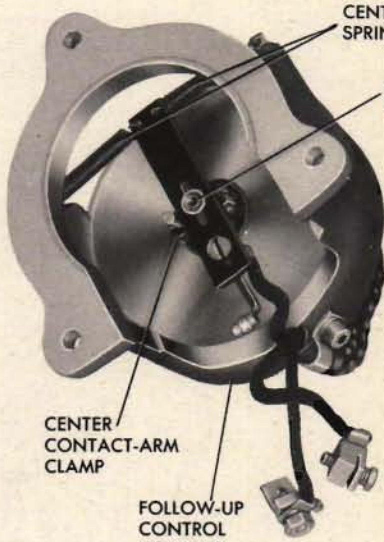


Jiggling

Jiggling is a series of low-amplitude, high-frequency oscillations of the output shaft which may occur when the input signal is not changing.

It may be caused by too closely spaced contacts, loose contacts or pigtail terminals, tight or stiff pigtails, or a faulty servo damper. A loose clamp connecting the center contact arm to the magnetic-drag rotor or a weak magnetic drag will also cause jiggling in the single-speed receiver.





Sluggishness

In turning to synchronize with the input signal, a servo may operate too slowly because of dirty contacts or a defective capacitor.

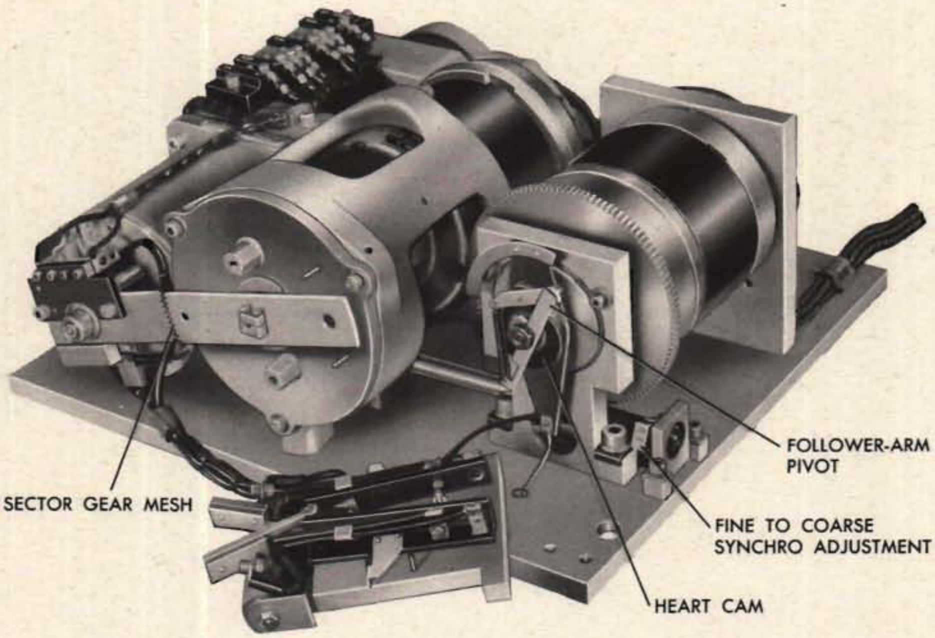
The contacts may be cleaned or the capacitor replaced and an operation test made while the receiver is still in the instrument.

CAUTION

Certain receivers are designed to lag behind the incoming signal an amount proportional to the rate of change of the signal. Operation in these receivers should not be confused with operation due to the above-mentioned casualties. If there is any doubt about the slowness of the receiver, the strength of the magnetic drag and of the contact centering springs should be checked against the assembly drawing.

Faulty synchronization

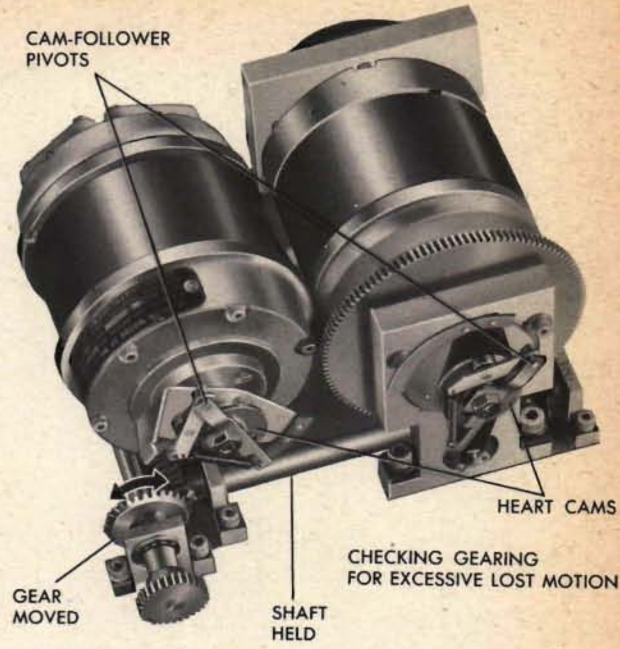
With a fixed input signal, a receiver may have either a poorly defined synchronization point or two separate synchronization points.



A poorly defined synchronization point may be caused by dirt or foreign material in the detent of the heart cam, by a jammed cam-follower pivot, by a tight sector gear mesh, by slipping or excessive lost motion in the follow-up control gearing, or by an open in a synchro stator circuit.

Synchronization at two separate points for a fixed input signal may be due to an open synchro rotor circuit or to a nick or piece of foreign material on the working surface of a heart cam. Improper adjustment between the coarse and fine synchros may cause the receiver to appear to synchronize at two points, but this will usually be accompanied by bucking.

Before removing the unit for repair, make the check tests as directed in the instrument OP's in order to eliminate the possibility of an open connection outside the unit or even outside the instrument.

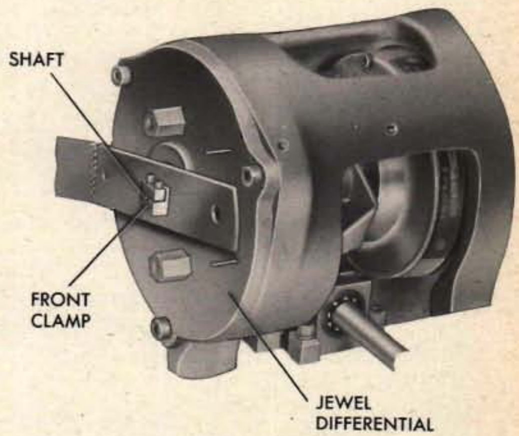


DOUBLE-SPEED RECEIVER SYNCHROS

Jamming or sticking of the cam-follower pivot or the sector gear mesh, dirt or nicks on the heart cam, or excessive lost motion or slipping of the follow-up control gearing may prevent perfect mechanical transmission of the synchro rotor position to the heart cam or contact assemblies.

Partial disassembly may be necessary in order to free a jammed or sticking pivot, but defects in the gearing or in the heart cams can often be eliminated without removing the unit from the instrument.

In the double-speed receiver, check to be sure that the sector clamps are tightened securely on the flat sides of the jewel differential shafts.

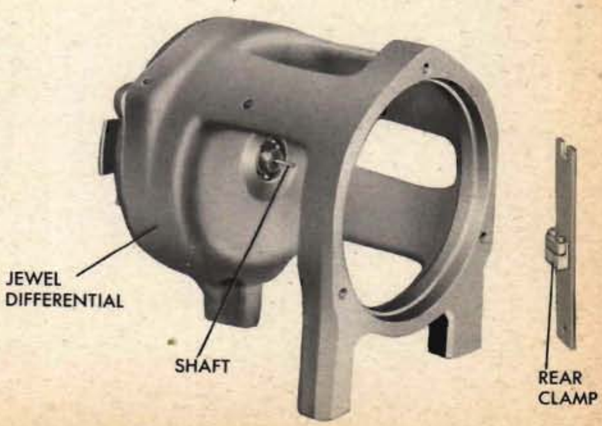


Noise and heat

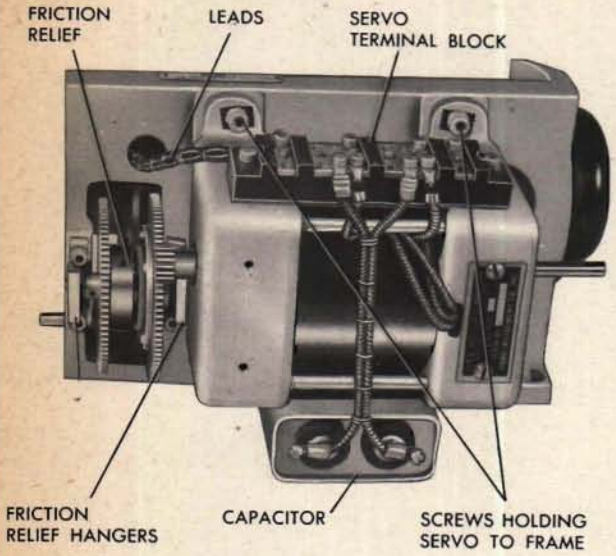
Noise may result from sticking or damaged gear teeth. This symptom usually occurs together with other symptoms such as roughness or a locked synchro rotor.

Excessive heat or a burned-out motor is usually caused by an open or a short circuit or a mechanical overload of the rotor. A current of higher amperage than the unit is designed to take then flows through the coils and generates sufficient heat to destroy the insulation and ruin the motor.

Before testing a receiver in which a burned-out synchro has just been replaced, check for open or short circuits in the receiver synchro wiring, and for mechanical causes of rotor overloading. Otherwise the new motor may burn out during the test.



Disassembling the single-speed unit



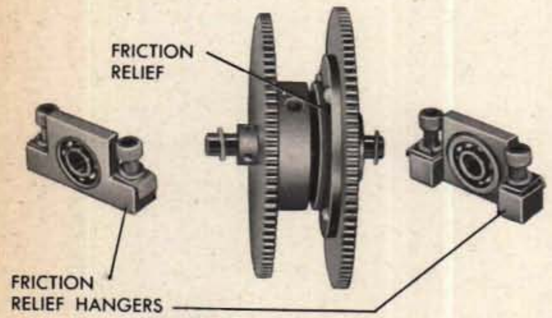
1 Remove the leads from the terminal block of the servo.

2 Remove the screws holding the servo and capacitor to the frame.

3 Lift out the servo and capacitor.

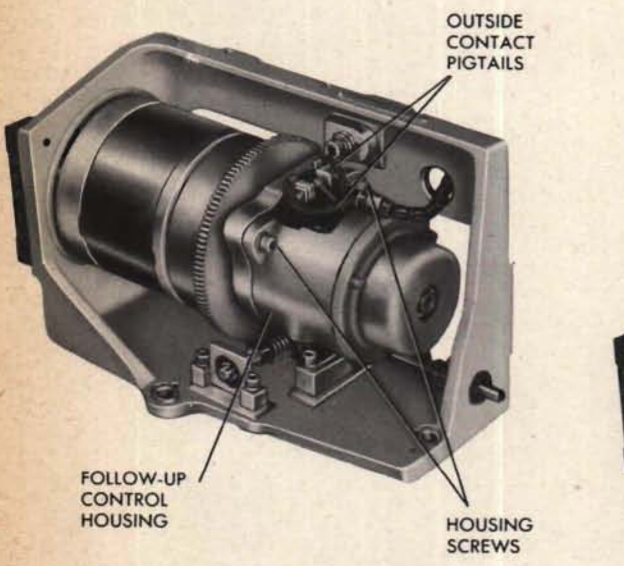
For instructions on the disassembly and repair of the servo motor, refer to page 426.

For instructions on checking the capacitor, refer to page 430.



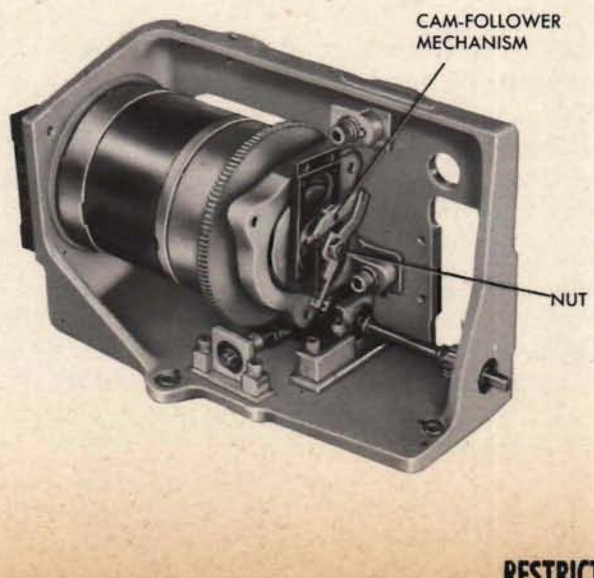
4 Remove the hangers and the friction relief.

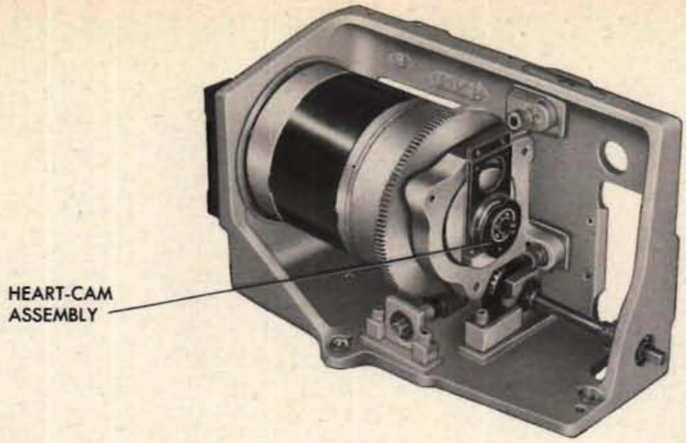
5 Disconnect the outside contact pigtails. Tag them.



6 Remove the follow-up control housing.

7 Remove the cam-follower mechanism by unscrewing the rotor nut.



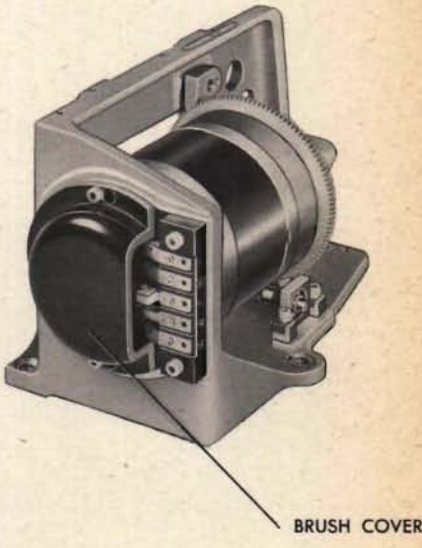


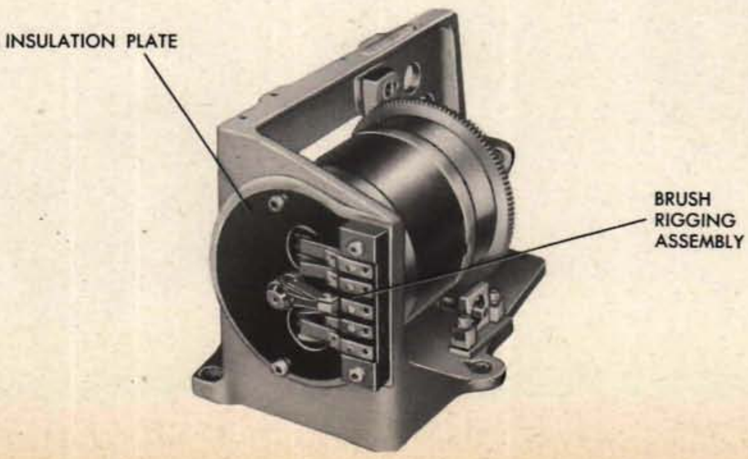
8 Remove the heart-cam assembly and spacer.

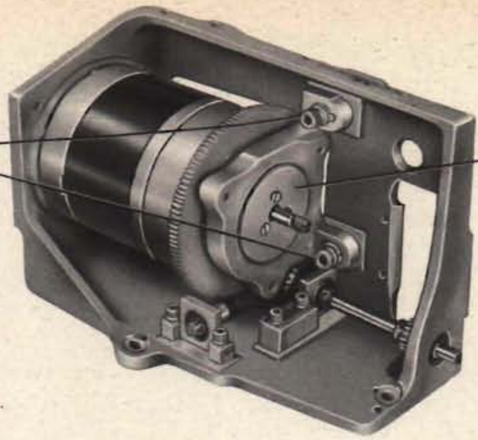
9 From the other end, remove the brush cover.

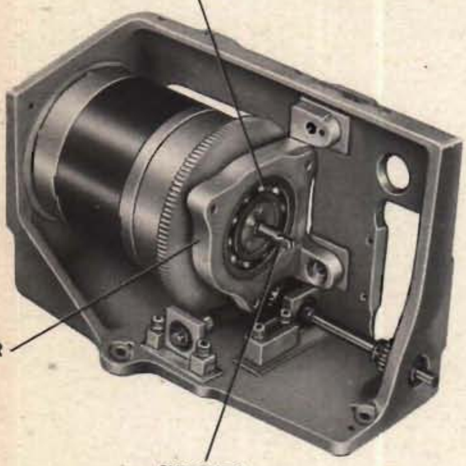
10 Remove the brush rigging assembly.

11 Remove the insulation plate.









12 Remove the retainer plate.

13 Unscrew the two screws which secure the large bearing hanger to the frame.

14 Gently lift the bearing hanger off its dowels. (If the dowel holes extend through the hanger feet, drive out the dowels before removing the hanger.) Remove the bearing from the hanger.

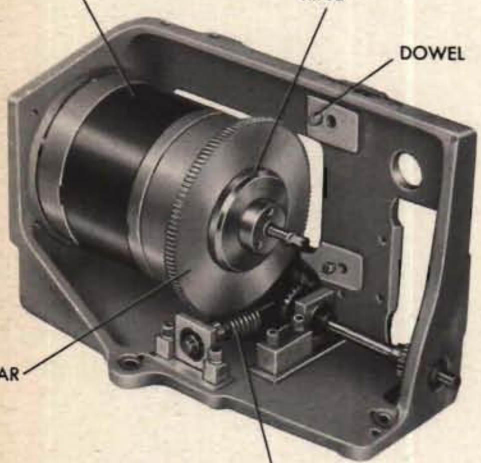
15 Remove the beveled ring.

16 Lift out the synchro motor. For instructions on disassembly of the synchro motor, refer to page 446.

17 Remove the gear only if necessary.

18 Remove the worm-shaft assembly only if necessary.

19 Remove the large bearing if it requires cleaning or replacement.

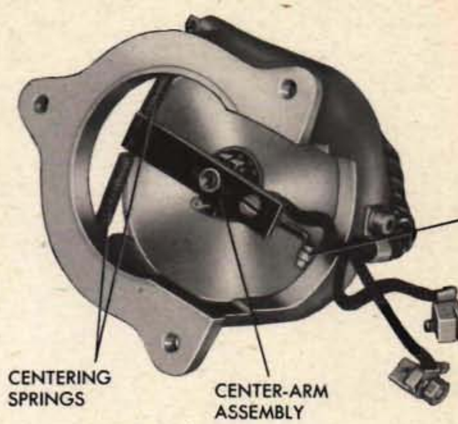


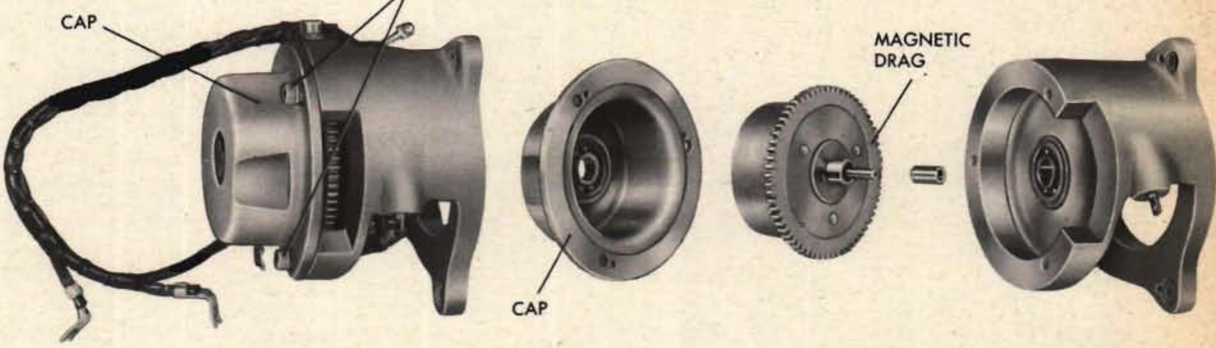
Removing the magnetic drag

20 Unhook the centering springs and loosen the clamp. Remove the center-arm assembly of the follow-up control. Tag the spacer.

21 Remove the three screws and lift off the cap.

22 Lift out the magnetic drag. Tag the spacers.





Repairing the single-speed unit

The synchro receiver is really an assembly of several basic units which are discussed in other chapters of this book. Therefore, refer to the following chapters on these units for instructions on repairing the parts of the receiver:

The Servo Motor, page 426.
The Synchro, page 444.
The Follow-up, page 402.
Basic Repair Operations, page 36.
Shaft Lines, page 92.
Wiring, page 380.

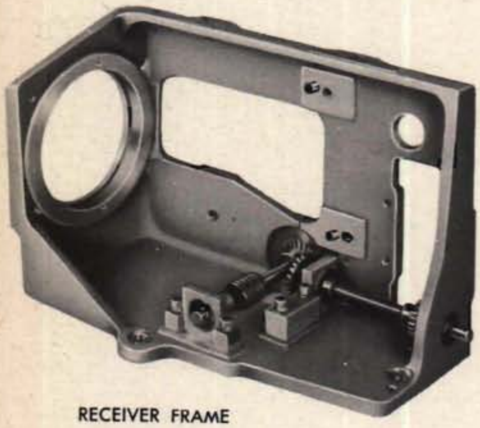
The magnetic drag

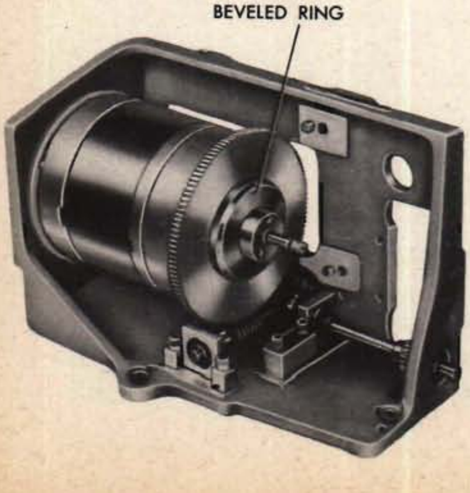
Do not disassemble the magnetic-drag subassembly unless a replacement magnetic drag or facilities for remagnetizing the drag are available.

A magnetic field generated by 40 to 60 thousand ampere-turns D.C. is required to remagnetize the drag. The magnetic drag is similar to the magnetic damper in principle and construction. For an explanation of the magnetic damper, see page 440.

Reassembling the single-speed unit

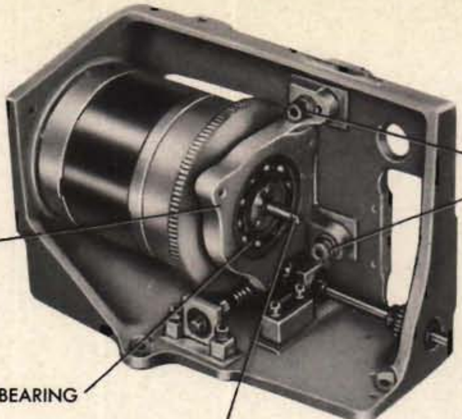
Wash the mechanical parts in an approved solvent and dry them. Apply some approved lubricant to each gear and bearing.



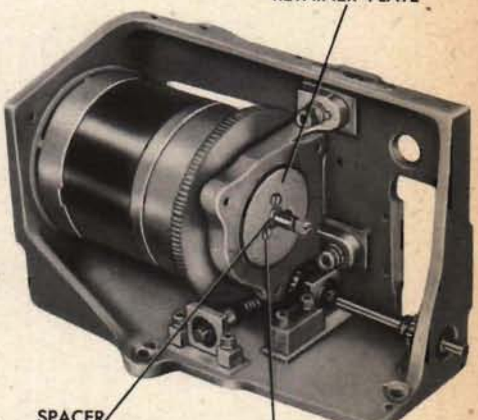


1 Mount the synchro, together with its bearing and gear, in the seat in the frame.

2 Mount the beveled ring on the gear.



3 Mount the hanger on the dowels and secure it with the two screws. Replace the bearing.



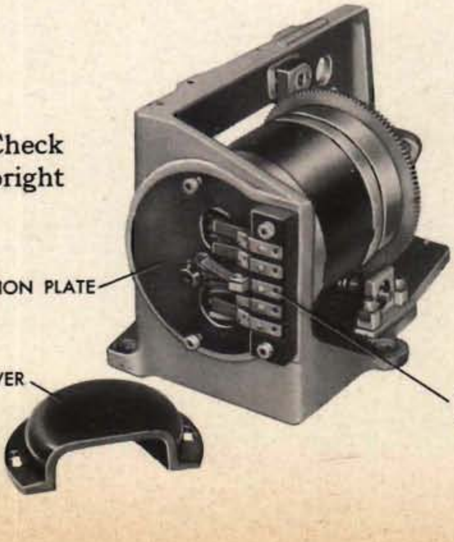
4 Mount the retainer plate and stake the three flat-head screws.

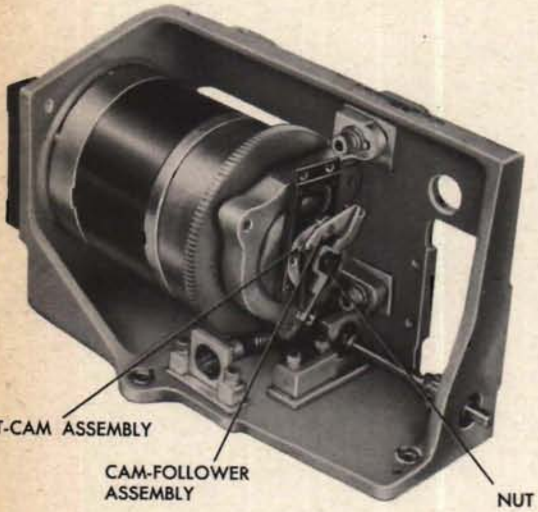
5 Put the spacer on the synchro shaft.

6 Mount the insulation plate.

7 Mount the brush rigging assembly. Check to be sure the contact surfaces are bright and clean and that contact is good.

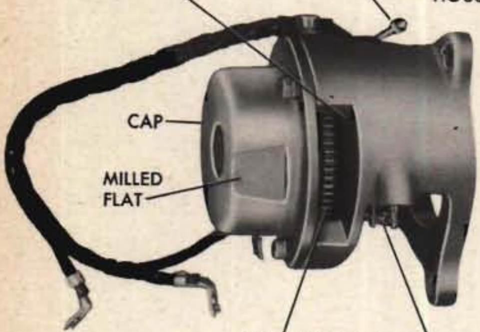
8 Mount the brush cover.





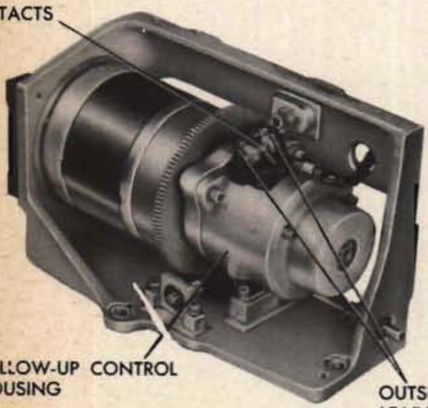
9 Mount the heart-cam assembly on the synchro rotor shaft.

10 Mount the cam-follower assembly and secure it with the nut.



11 Install the magnetic drag in the housing with its spacers. Replace the cap being sure to have the milled flat on the side of the cap opposite the cutaway in the housing.

12 Mount the center contact arm and spacer on the magnetic drag shaft and tighten the small assembly clamp. Replace the centering springs.



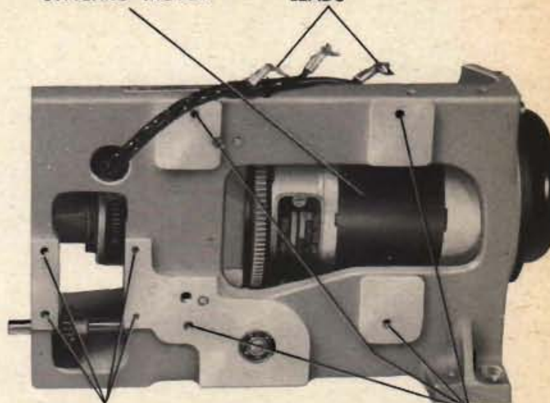
13 Mount the follow-up control housing.

14 Install the outside contacts and leads and adjust the contacts.

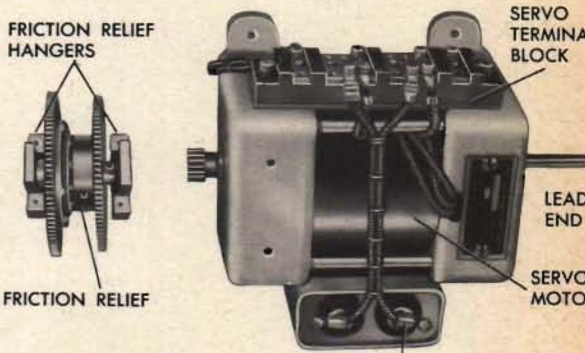
15 Mount the friction relief and its hangers.

16 Mount the servo motor and capacitor.

17 Connect the leads to the servo terminal block.



Bench checking the single-speed unit



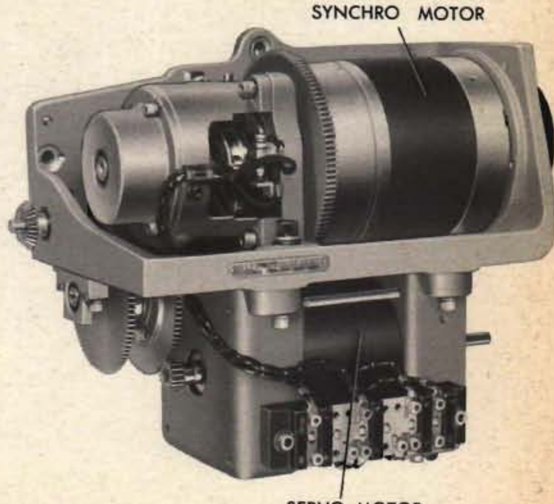
1 Check the assembly of the unit against the assembly drawing.

2 Gear meshes should be free with a minimum of lost motion.

3 Contacts should be aligned to meet squarely. Be sure they are adjusted close enough to reduce the dead space to a minimum without causing arcing or jiggling.

4 Check to be sure that there are no grounded wires. Check to be sure that fish paper has been placed under the wire clamps.

5 Apply 115-volt A.C. to single and double-letter terminals of the servo motor block. When the contacts are offset by hand, the motor should run in the direction which corresponds with the contact being made. The No. 1 contact should cause the motor to run clockwise as viewed from the lead end of the motor.



6 Connect a synchro generator to the receiver synchro and energize the follow-up. With a fixed input signal, the receiver should synchronize and hold steady in agreement with the signal.

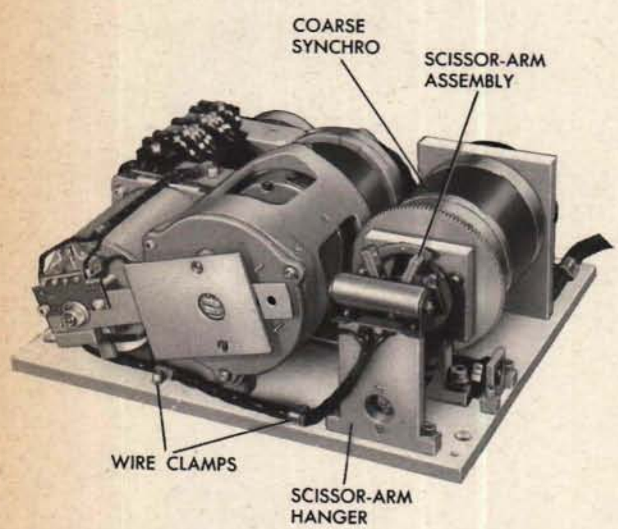
7 When the input signal is varied the receiver should follow smoothly.

8 Check to be sure that the friction relief is set according to instructions on the assembly drawing.

Disassembling the double-speed unit

The major assemblies of a double-speed receiver may be removed and disassembled independently. The procedure will be described in the following order:

Removing the coarse synchro assembly.
Removing the fine synchro motor and jewel differential assembly.
Removing the servo motor and compensator assembly.
Removing the contacts and wires.



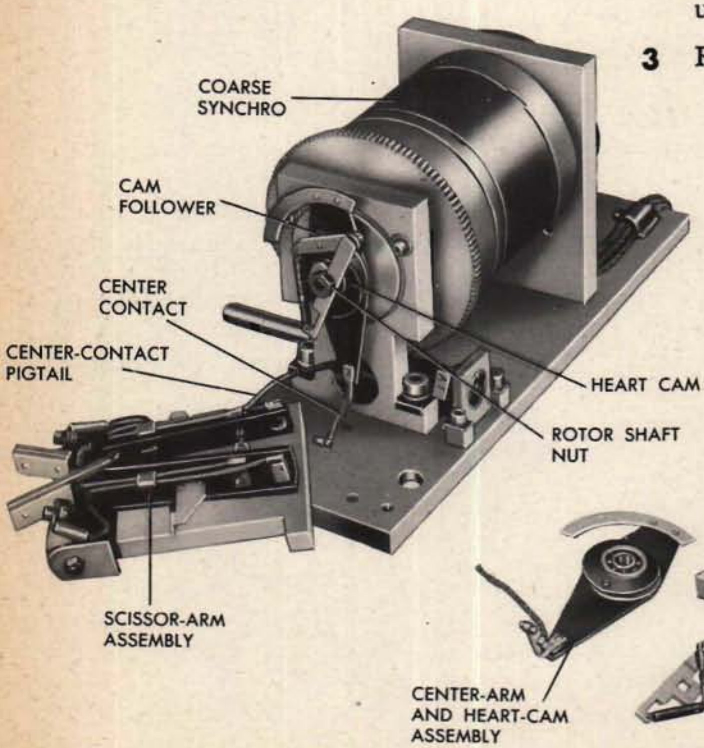
DOUBLE-SPEED RECEIVER

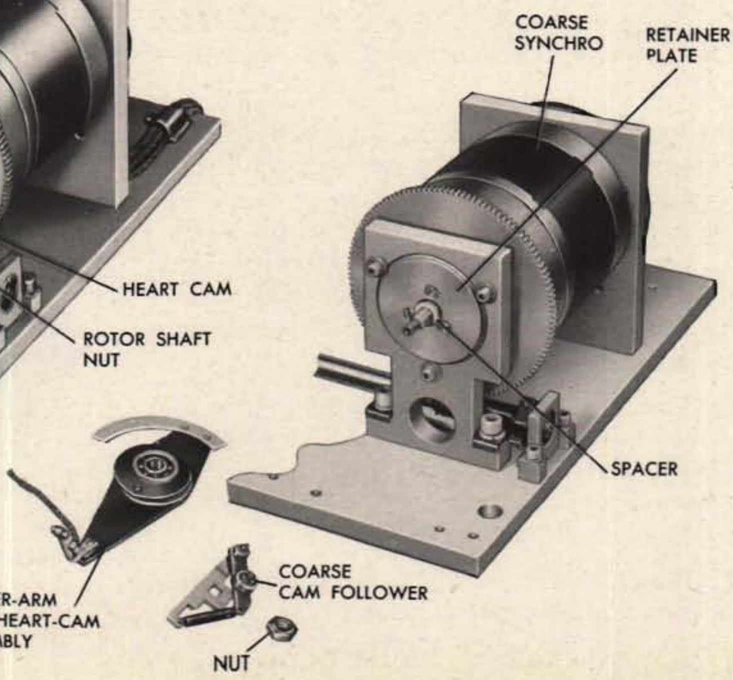
Removing the coarse synchro assembly

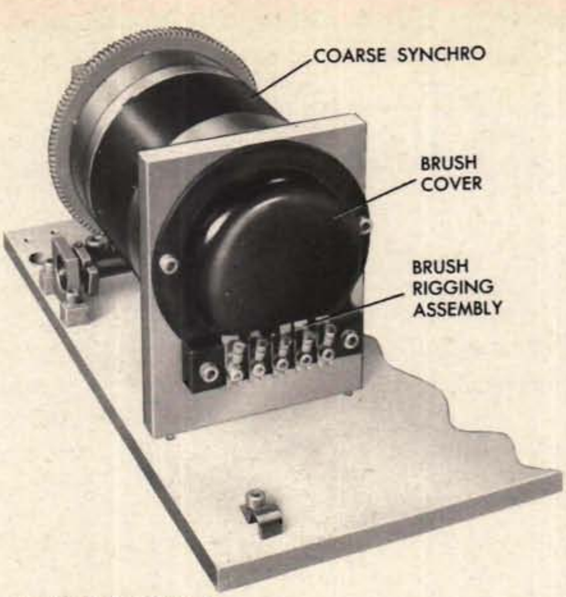
1 Remove the scissor-arm hanger to which the scissor-arm assembly and coarse synchro contacts are attached. The pigtail will remain attached to the coarse center contact. Remove the wire clamps.

2 Remove the coarse cam follower and the center-arm and heart-cam assembly by unscrewing the nut from the rotor shaft.

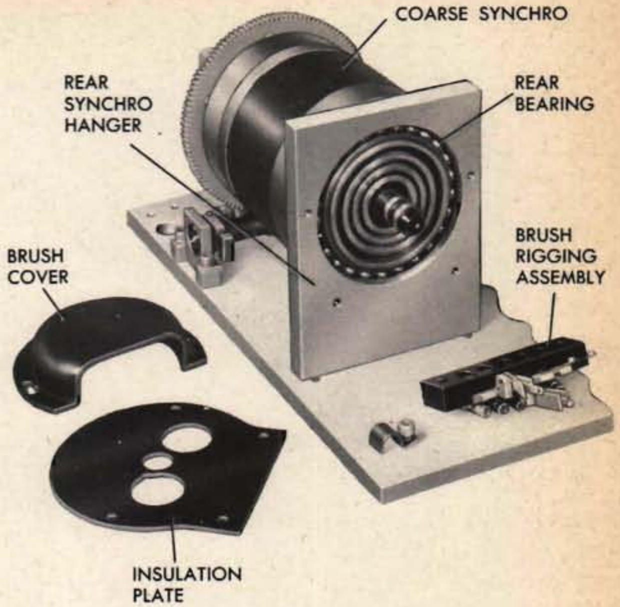
3 Remove the retainer plate and spacer.







COARSE SYNCHRO
REAR VIEW

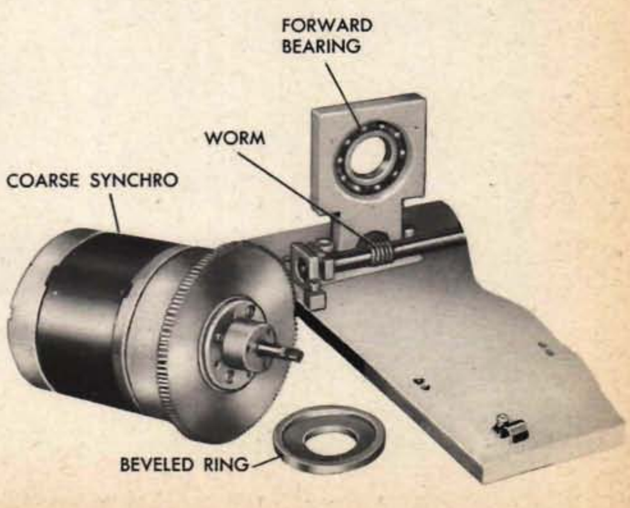


4 Remove the brush cover, the brush rigging assembly, and the insulation plate.

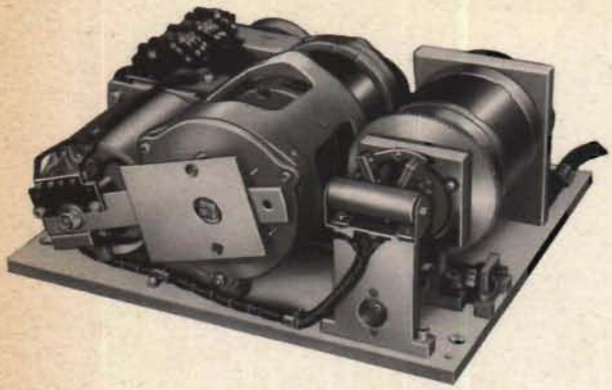
5 From the bottom of the plate, loosen the screws of the rear synchro hanger and pull off the hanger and bearing.

6 Pull the coarse synchro out of its forward bearing and remove the beveled ring from the big gear.

7 If necessary, remove the worm which is mounted between hangers on the base plate.

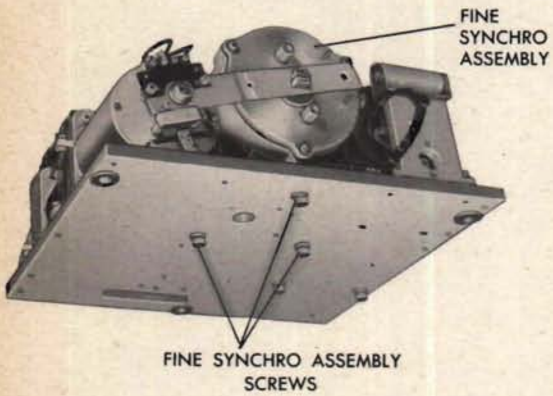


Removing the fine synchro motor and jewel differential assembly



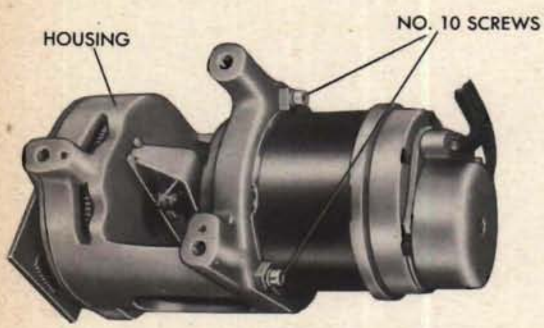
DOUBLE-SPEED RECEIVER

1 Loosen the three ¼-20 screws on the bottom of the plate and gently lift up the housing to remove the fine synchro assembly. The legs are doweled. Be careful not to injure the delicate jewel differential shaft.



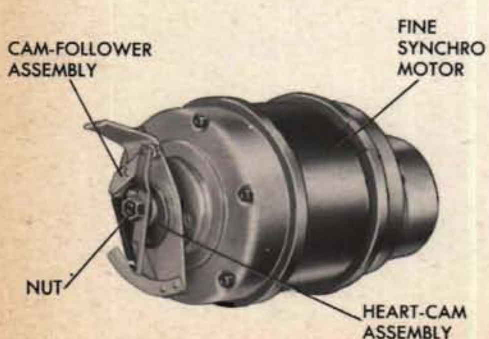
2 Loosen the three No. 10 screws and lift out the synchro.

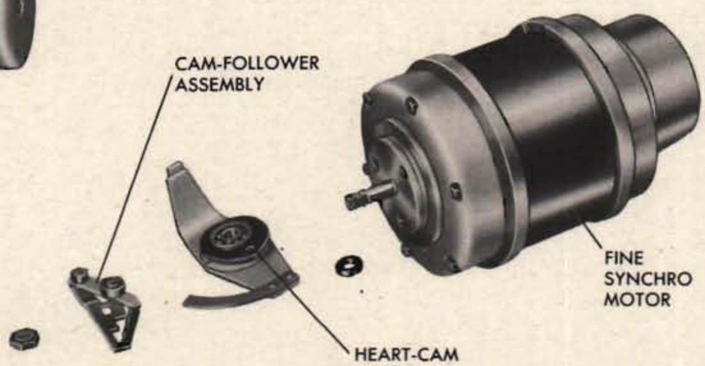
3 Loosen the nut on the rotor shaft and remove the cam-follower and heart-cam assemblies.

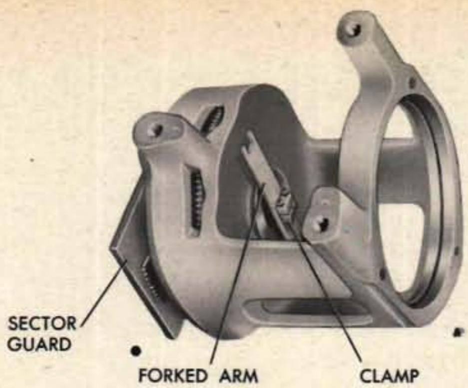


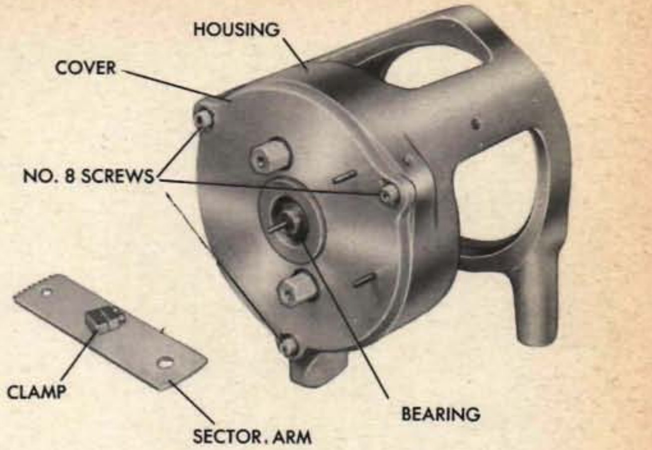
FINE SYNCHRO ASSEMBLY

4 If the synchro motor needs repairing, refer to page 444.

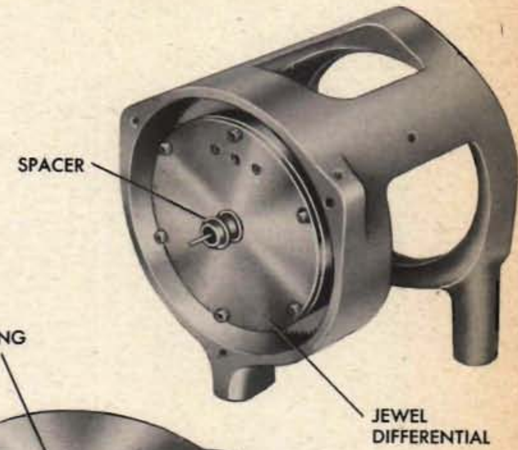




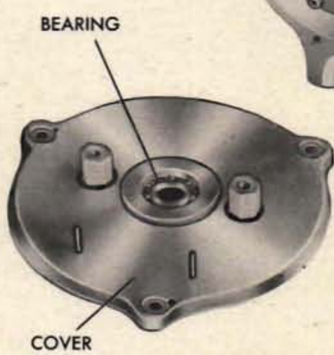




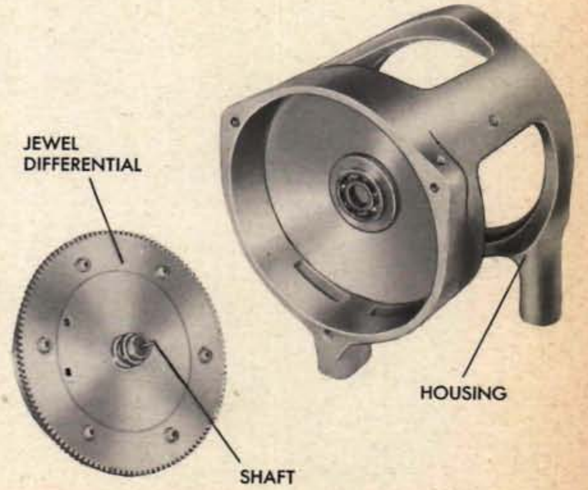
5 Remove the forked arm from the jewel differential by loosening the clamp.



6 Remove the sector guard. Loosen the clamp and remove the sector arm from the jewel differential.



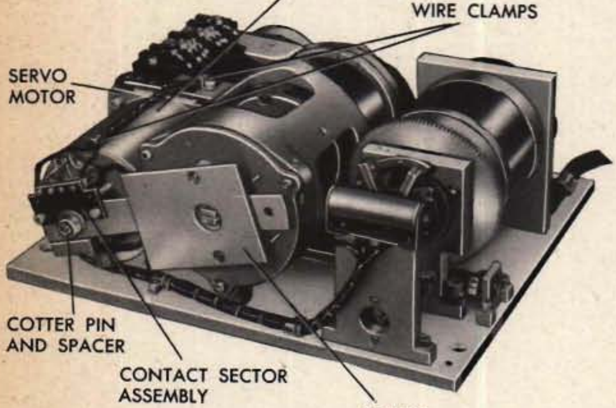
7 Loosen the three No. 8 screws and remove the cover from the housing. Tag the spacer and the bearings.



8 Remove the jewel differential by pulling it carefully out of its rear bearing in the housing. Handle the jewel differential with extreme care. *Provide a support for the jewel differential so that its shafts will not touch the bench. Shock or other mistreatment may break a shaft or crack a jewel bearing.*

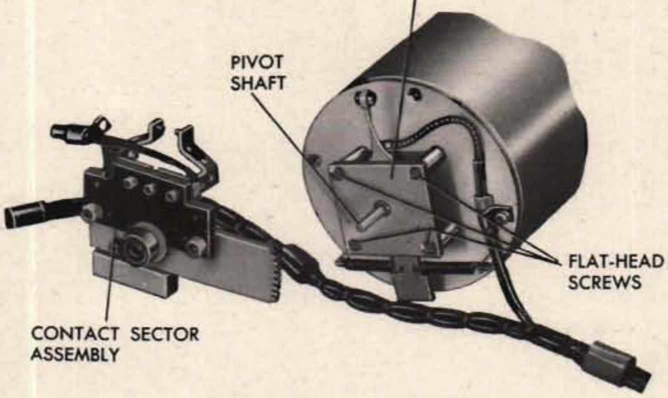
9 For instructions on disassembling the jewel differential, refer to page 182.

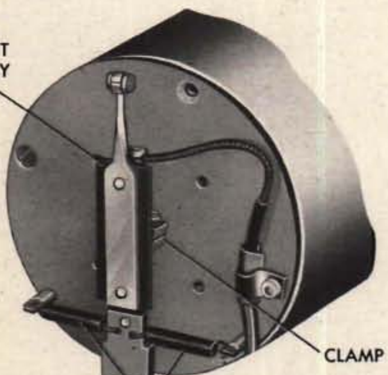
Removing the servo motor and compensator assembly



DOUBLE-SPEED RECEIVER

1. Remove the wire clamps and sector guard.
2. Pull out the cotter pin. Remove and tag the spacer.
3. Pull the contact sector assembly off the pivot shaft.
4. Unscrew the four flat-head screws and remove the pivot shaft mounting.



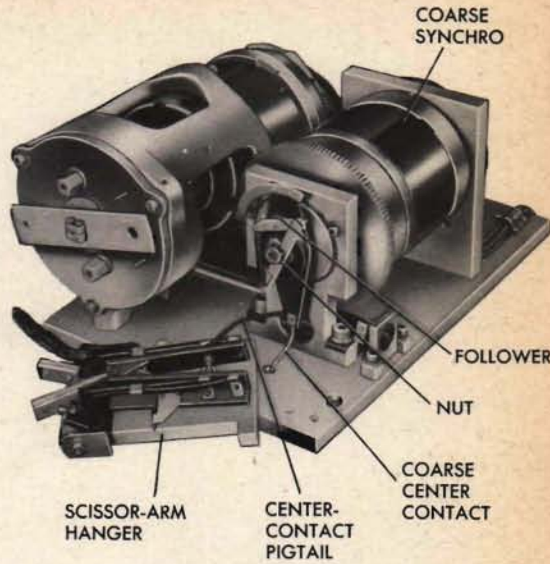


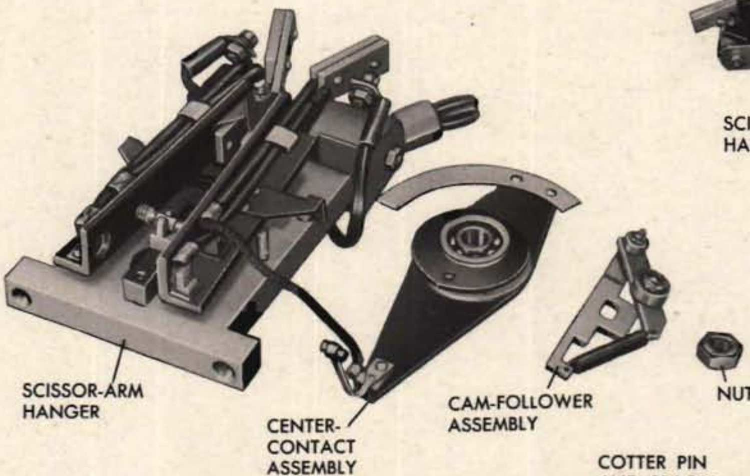
5. Unhook the centering springs, loosen the clamp, and lift off the center contact assembly.
6. Disconnect the leads from the servo motor block.
7. Unscrew the No. 10 screws in the motor feet and remove the motor and compensator assembly. For instructions on disassembling the servo motor, refer to page 426. For instructions on disassembling the compensator and removing the magnetic drag, refer to page 413.

Removing the contacts and wires

1 Remove the coarse scissor-arm hanger. **CAUTION:** Do not pull the hanger away. It is connected to the center pigtail.

2 Loosen the nut on the coarse synchro rotor and remove the coarse cam follower and center-contact assemblies.





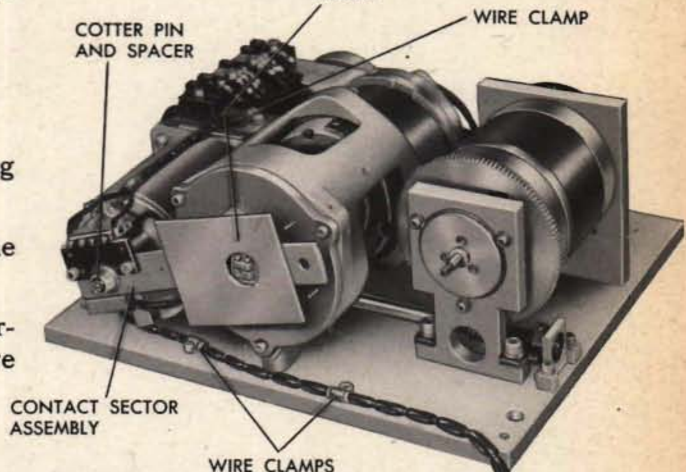
3 Remove the wire clamps.

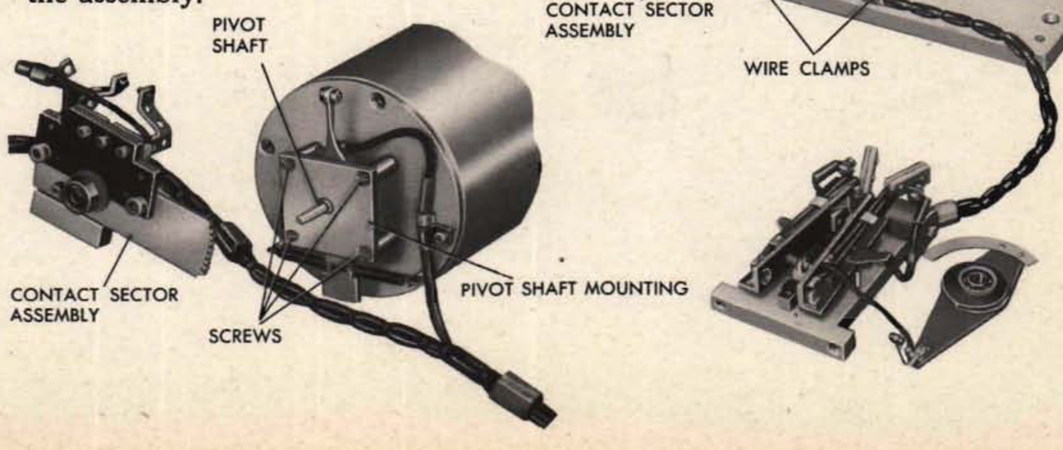
4 Remove the sector guard.

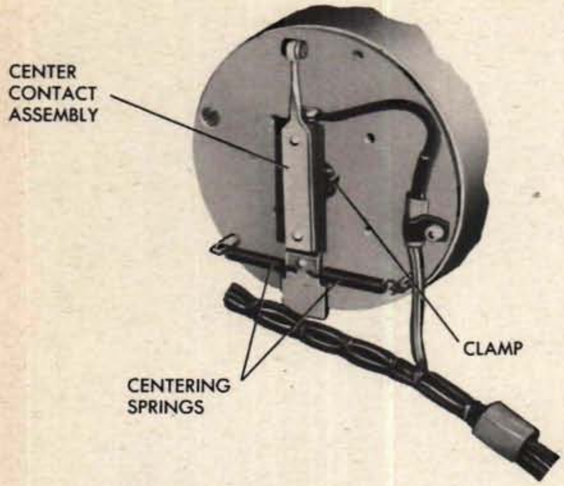
5 Pull out the cotter pin. Remove and tag the spacer.

6 Take the contact sector assembly off the pivot shaft.

7 Unscrew the four flat-head screws securing the pivot shaft mounting and remove the assembly.



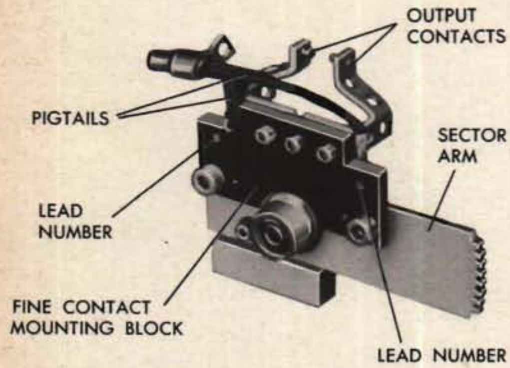




8 Loosen the clamp on the center-contact assembly.

9 Unhook the centering springs and remove the center-contact assembly.

10 Disconnect the leads from the servo motor block.

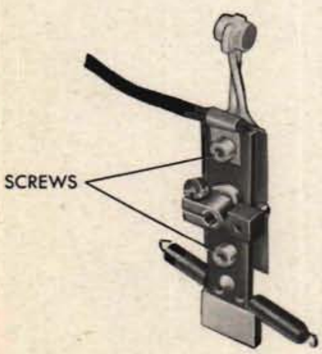


SECTOR ASSEMBLY

11 Remove the fine outside contacts from the contact sector assembly.

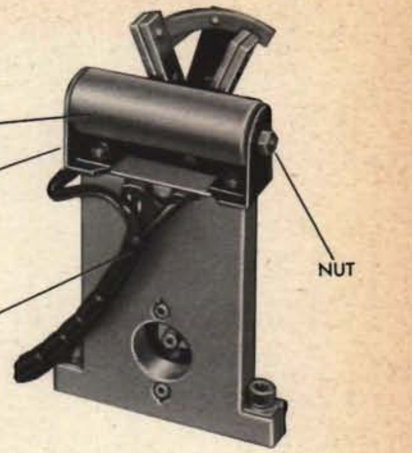
12 Tag the pigtails with numbers corresponding to those stamped on the mounting block.

13 Remove the fine contact mounting block and the counterweight from the sector arm.



FINE CENTER-CONTACT ASSEMBLY

14 Loosen the screws holding the fine center-contact assembly together. Take the assembly apart.

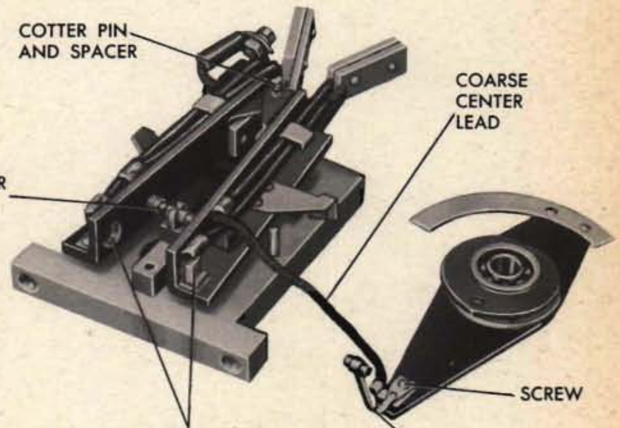


15 Unscrew one of the nuts and pull the rod out of the resistor.

16 Remove the resistor brackets to free the pigtails.

17 Remove the coarse center lead and contact arm by taking out the small flathead screw.

18 To remove the scissor arms, pull out the cotter pin and remove the spacer.



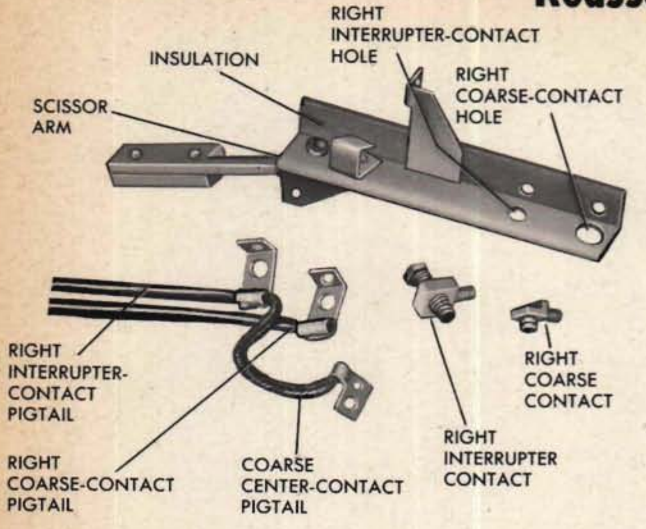
19 Remove the interrupter contacts and coarse outer contacts. Tag leads corresponding to stampings on scissor arms.

Repairing the double-speed unit

The double-speed synchro receiver is really an assembly of several basic units which are discussed in other chapters of this book. Therefore, refer to the following chapters on these units for instructions on repairing the parts of the receiver:

Basic Repair Operations, page 36.
Shaft Lines, page 92.
The Jewel Differential, page 182.
Wiring, page 380.
The Follow-up, page 402.
The Servo Motor, page 426.
The Synchro, page 444.

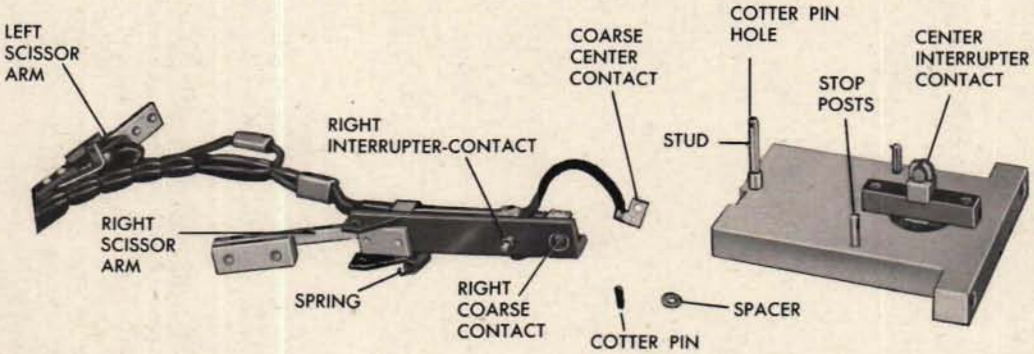
Reassembling the double-speed unit

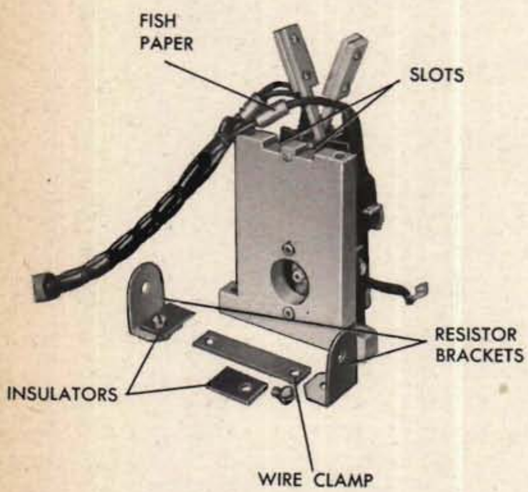


1 Attach the pigtails and contacts to the scissor arms. The tags attached to the wire terminals should correspond to the numbers stamped on the insulating material.

2 Place the scissor arms on the stud, keeping the arms between the stop posts. Secure them with the spacer and cotter pin, making sure that they pivot freely on the stud.

3 Attach the spring that holds the arms together.

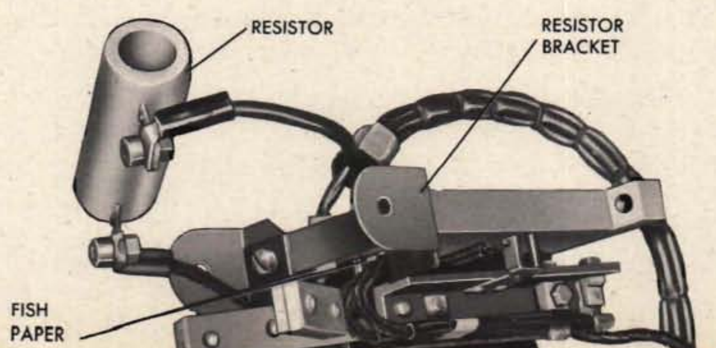


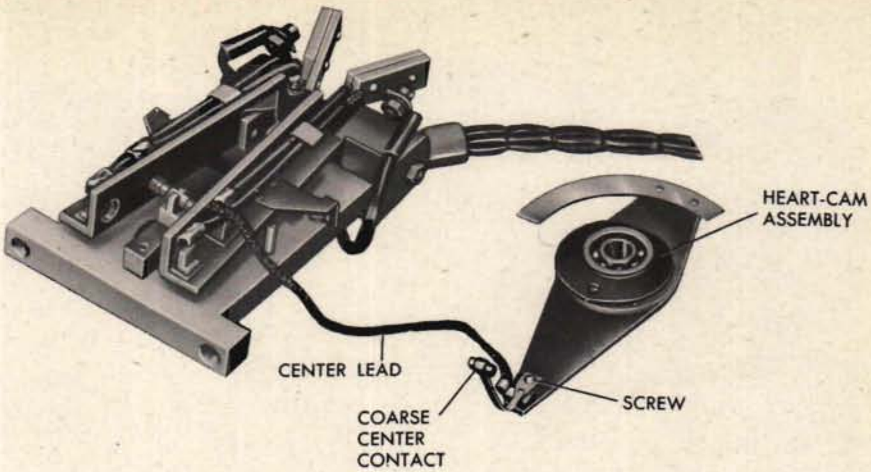


4 Cover the pigtails with fish paper and insert them in the slots.

5 Mount the wire clamp, resistor brackets, and insulators, with the insulators extending toward the scissor arms.

6 Put the resistor, the aluminum washers, and the mica insulators in place between the brackets. Insert the rod and tighten the nuts.

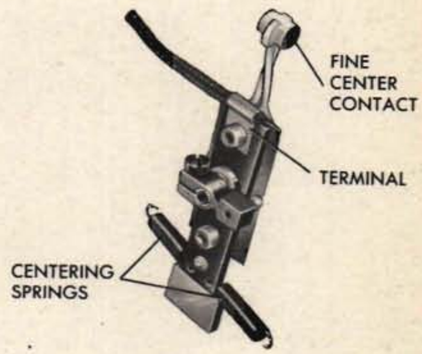




7 Screw the center lead and coarse center contact to the heart-cam assembly.

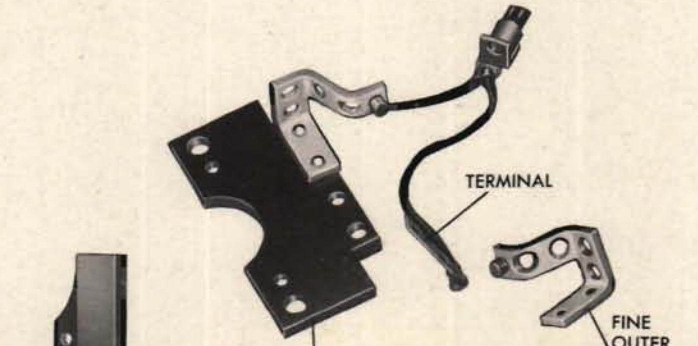
8 Reassemble the fine center contact and terminal.

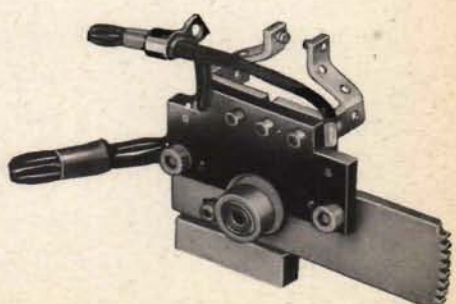
9 Assemble the fine outer contact supports and terminals. Screw them to the mounting block. Attach the terminals according to the tags attached at disassembly.



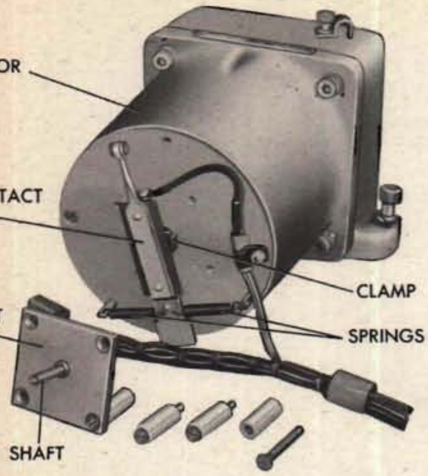
FINE CENTER-CONTACT ASSEMBLY

10 Assemble the fine outer contacts and the counterweight on the sector.





FINE OUTER CONTACTS
AND SCISSOR-ARM ASSEMBLY



11 Mount the fine center-contact assembly on the magnetic drag shaft extension.

12 Attach the center-contact springs and tighten the clamp.

13 Replace the contact sector pivot shaft mounting on the compensator cover. Stake the four flat-head screws.

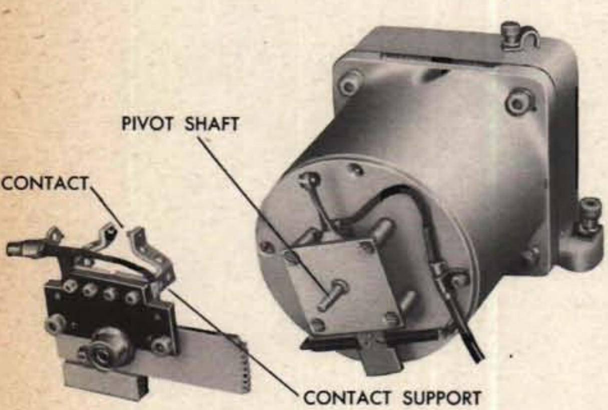
14 Slip the contact sector assembly and the spacer on the pivot shaft. Secure them with a cotter pin.

15 Adjust the outside contacts by moving their supports within the clearance of the mounting holes. The contact surfaces should be made parallel with a total gap of about 0.015 inch.

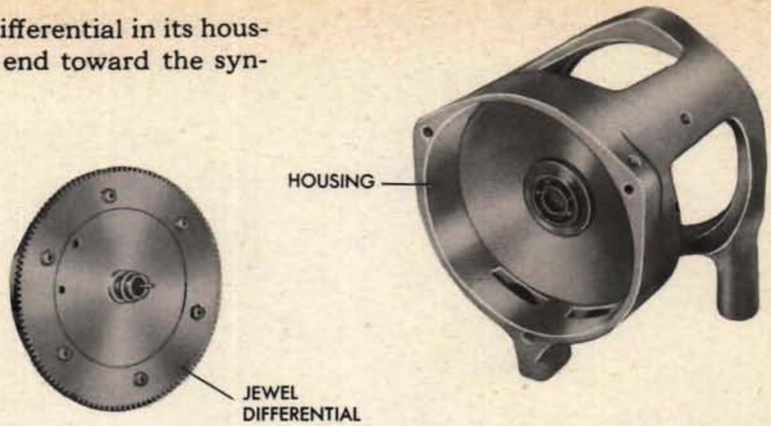
16 Mount the servo motor and compensator assembly on the plate.

17 Connect the leads to the servo terminal block.

18 Replace the wire clamps.

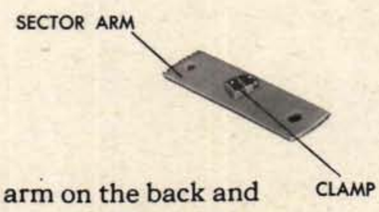


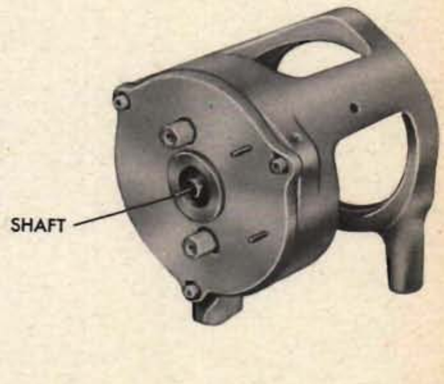
19 Mount the jewel differential in its housing with the gear end toward the synchro.



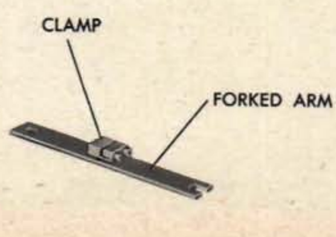
20 Replace the cover and bearing.

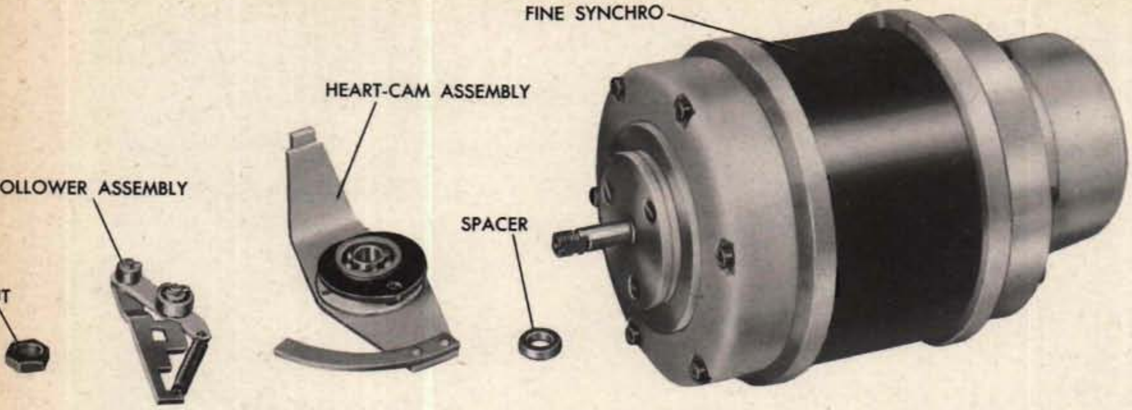
21 Replace the sector arm. *Be sure that the clamp is tightened on the flat of the shaft.*

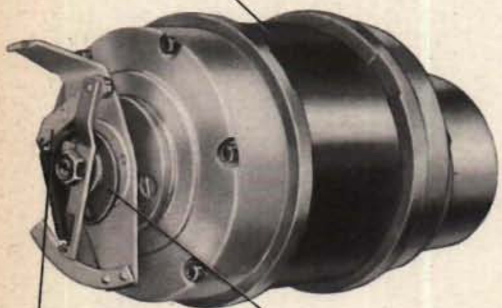




22 Replace the forked arm on the back and tighten the clamp on the flat of the shaft.



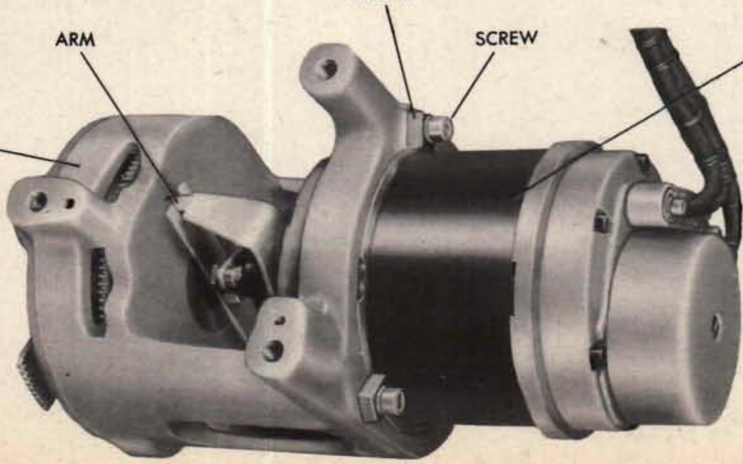


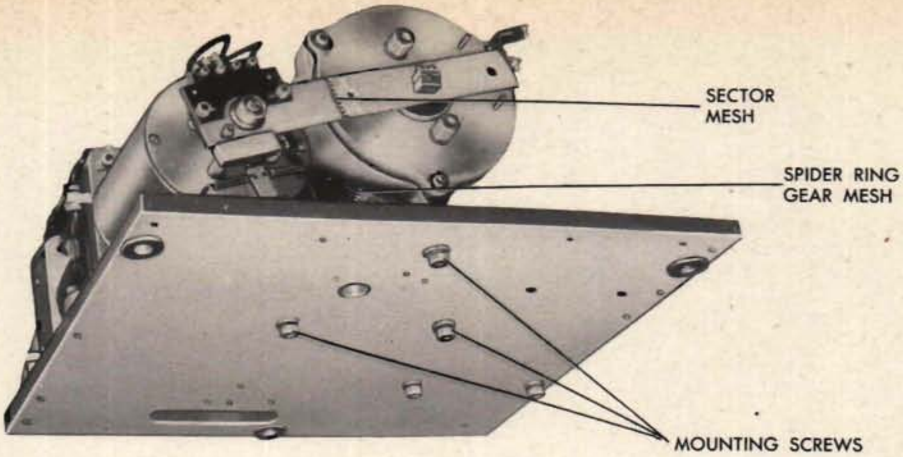


23 Mount the spacer and heart-cam assembly on the synchro rotor shaft.

24 Mount the cam-follower assembly and secure it with the nut.

25 Mount the fine synchro in the housing, carefully engaging the arm on the heart-cam assembly in the forked arm on the jewel differential. Secure the synchro with the blocks and screws.

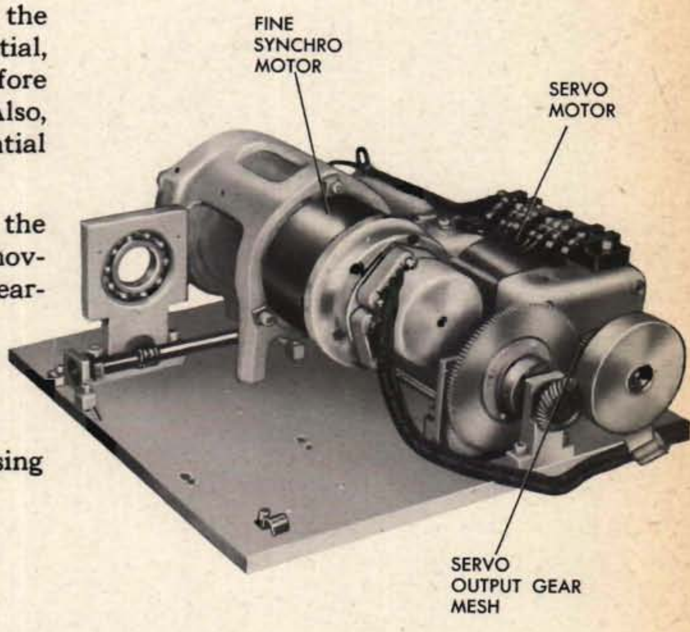




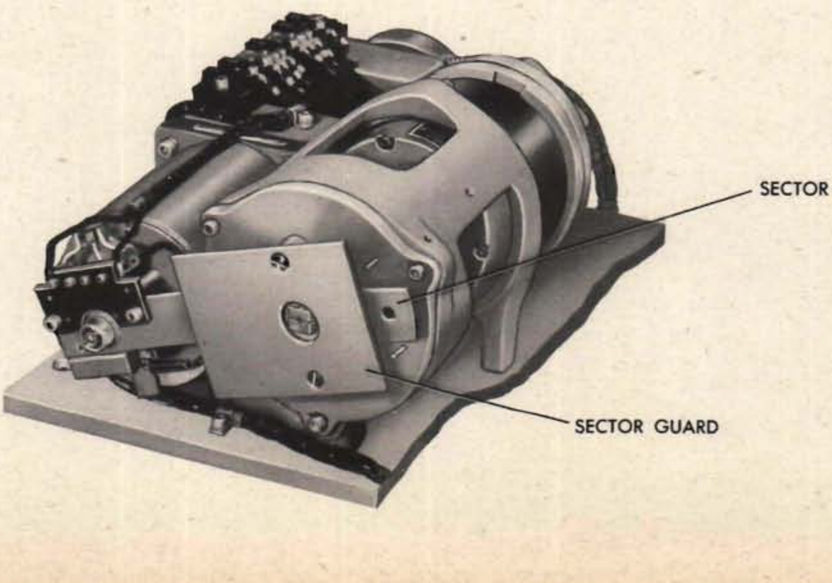
26 Remount the fine synchro assembly on the plate.

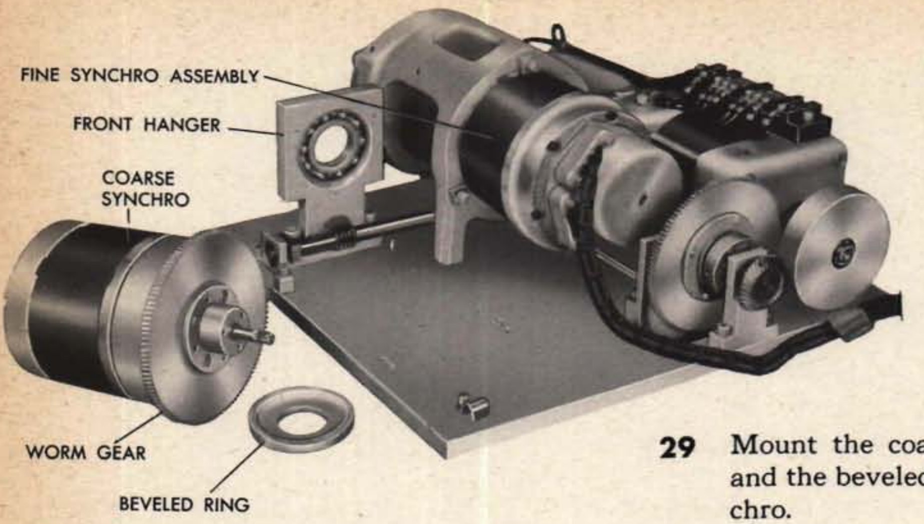
CAUTION: To avoid damage to the spider ring gear on the jewel differential, be sure that it is properly meshed before screwing the housing to the plate. Also, avoid straining the jewel differential shaft when meshing the sectors.

27 Adjust the sector gear mesh and the servo motor output gear mesh, by moving the servo motor within the clearance of the mounting holes.



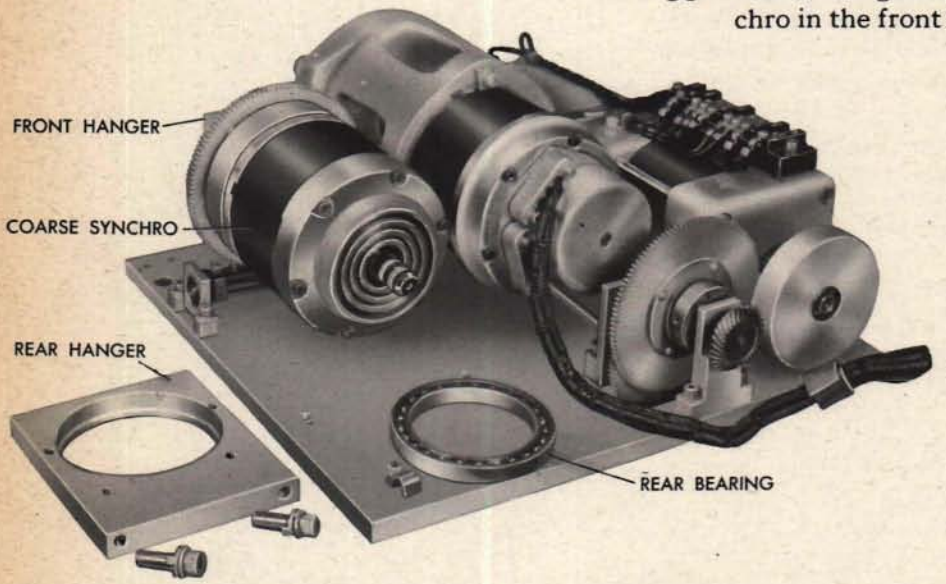
28 Mount the sector guard on the housing cover.





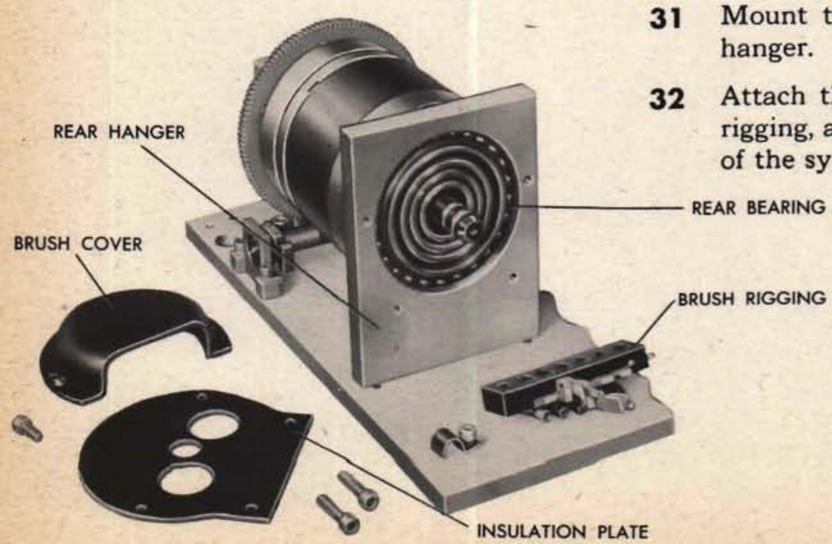
29 Mount the coarse-synchro worm gear and the beveled ring on the coarse synchro.

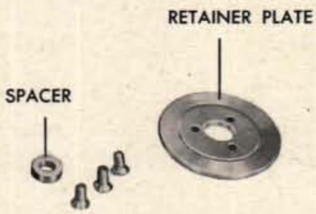
30 Insert the gear end of the coarse synchro in the front hanger.

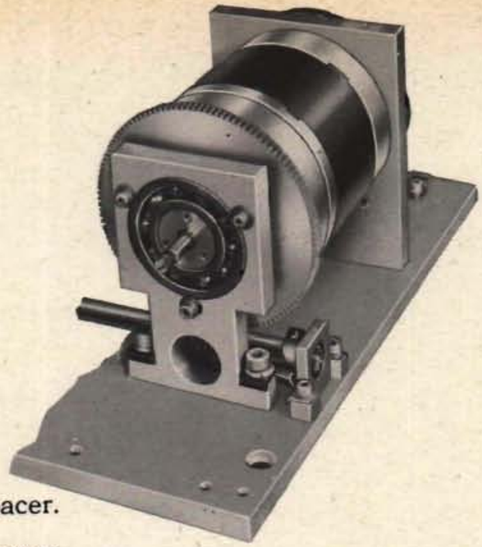


31 Mount the rear bearing and the rear hanger.

32 Attach the insulation plate, the brush rigging, and the brush cover to the rear of the synchro.

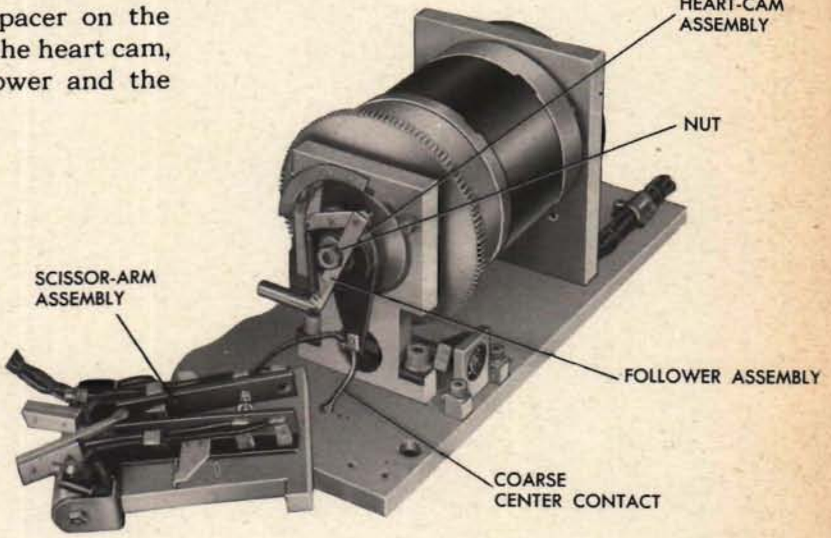






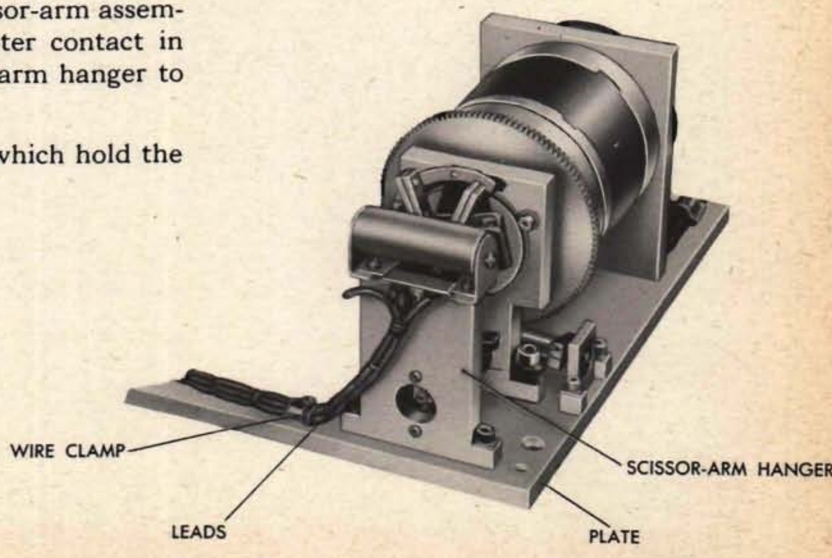
33 Replace the retainer plate and spacer.

34 Mount the heart-cam and cam-follower assemblies. First put a spacer on the synchro rotor shaft, then the heart cam, and finally the cam follower and the nut.



35 Carefully mount the scissor-arm assembly with the coarse center contact in place. Screw the scissor-arm hanger to the plate.

36 Secure the wire clamps which hold the leads to the plate.



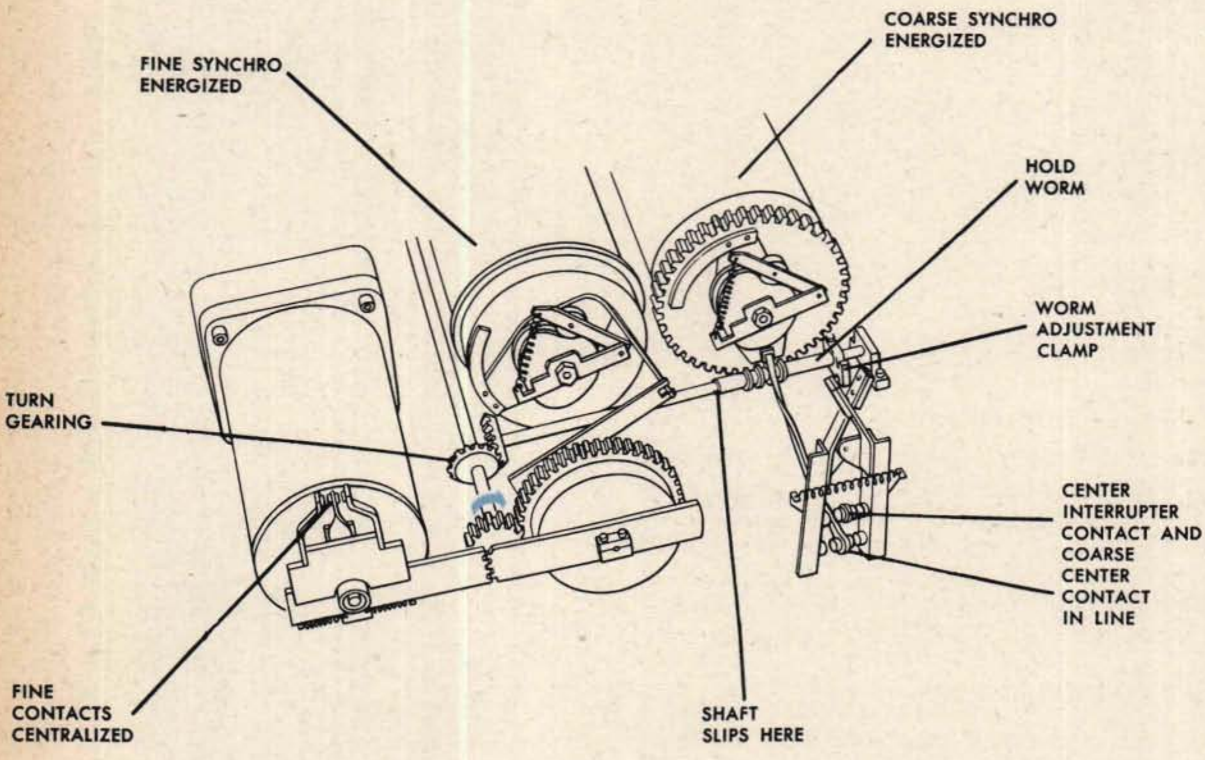
Adjusting the electrical relationship

1 Wire a transmitter to the receiver. In order to insure correct rotation, carefully observe standard Navy wiring practice. The fine and coarse generators of the transmitter must be geared together in the same ratio as the receiver motors and have proper electrical relationship to each other.

2 With the servo power OFF, energize the two synchros. Adjust the worm clamp so that it is slip-tight.

Turn the gearing by hand until the coarse center contact is exactly in line with the center interrupter contact.

3 Keep the coarse synchro stator in this position by holding the worm and turn the gearing further until the fine center contact is midway between the two outside contacts. Tighten the worm adjustment clamp.



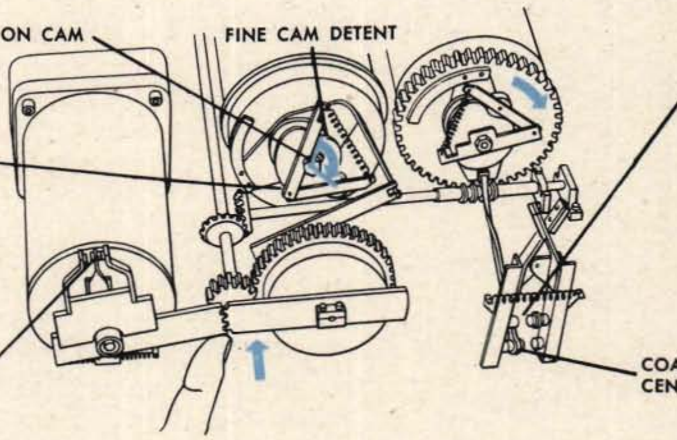
Adjusting the interrupter contacts

1 Screw in each of the outside contacts an equal number of turns.

2 Energize the servo motor.

3 Offset the fine contacts so that the motor drives the coarse stator to the point where the coarse center contact makes and the interrupter contacts open. For each direction of rotation, observe how far the fine cam follower travels out of the heart-cam detent, before the interrupter contacts open.

4 Adjust the interrupter contacts to open when the fine cam follower is one-half to two-thirds of the distance from the heart-cam detent to the peak.



Bench checking the double-speed unit

1 All gear meshes should be free and have a minimum of lost motion.

2 All taper pins should be staked and all set screws removed.

3 The fine contacts should be aligned to meet squarely and should have a total gap of about 0.015 inch. (In certain applications of the double-speed receiver, the required contact gap may be between 0.005 inch and 0.010 inch.)

4 Check to be sure that there are no grounded wires.

5 Wire a pair of standard generators according to standard Navy wiring practice and energize the servo and both synchro motors. The receiver should synchronize at one point and stand still. The receiver should smoothly follow changing signals from the transmitter. When the transmitter is turned in the increasing direction, the receiver output should also increase.

6 The friction relief should slip at the torque value indicated on the assembly drawing.